

CHAPTER VI.—DESCRIPTIONS OF QUARRIES AND QUARRY REGIONS.

GENERAL REPORT ON THE BUILDING STONES OF RHODE ISLAND, MASSACHUSETTS, AND MAINE.

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In the following report I propose to give a short general account of the geological conditions in which the building stones of these states occur, with some remarks on the conditions that have retarded or favored the development of quarrying industry within their limits. This discussion will not include any matters of a purely scientific character, nor will it have to do with the statistical matters presented in the tables. The end in view will be the presentation of the most important facts connected with the quarrying industries that have not been made clear in the statistical reports.

GENERAL CONDITIONS OF THE BUILDING STONES OF NEW ENGLAND.

It is a fact well known to geologists that the New England peninsula, or the region east of the Hudson and of lake Champlain, has a more varied geological structure than is found in any other region of equal area within this continent. In the manifold nature of its geological elements it more nearly resembles the territory of old England than that of the rest of America. As the possible variety of the building stones in any country depends upon the number of kinds of rock that appear at the surface of the earth, this variety in the geological structure of New England has exercised a beneficial influence on the quarrying industry within its bounds. A much greater variety of rocks is quarried within its limits than in any other equal area of America. The greater part of these quarry products is derived from the very ancient rocks which owe their utility to the extensive metamorphism to which they have been subjected by the action of heat and pressure. Nearly all the rocks in this region have lost their original character, being much denser and more crystalline, and are frequently penetrated by joints and cleavage planes that at certain places and for certain purposes are a great advantage to the quarryman.

The following list of native quarried stones used in New England for building will give an idea of the variety of materials existing within this area. In the list the distinctly-bedded rocks which have been but little changed from their original condition are given first; below these the more highly metamorphosed materials. Considerable as this list is, it affords but an inadequate idea of the actual variety of these materials, inasmuch as it is not possible to set out in such a list the lesser differences that often serve greatly to alter the appearance and the use of particular stones. Moreover the purposes to which the stone is applied are often too numerous to be set forth in such a brief statement.

LIMESTONES.

WHITE MARBLE.—Ranging from qualities only a little less perfect than that of Carrara to blotched and variegated stone; used for building stone and the various minor structural and ornamental purposes to which such stone is usually applied.

RED MARBLE.—Mostly used for building purposes and for table-tops, floors, etc.

BLACK MARBLE.—For inlay work, floors.

All the limestones that are quarried in New England are crystalline in their texture and are tolerably free from admixture of clay or magnesia; they are therefore all available for making lime and are largely used for this purpose. In their distribution they follow somewhat peculiar conditions. They are most abundant in western New England; *i. e.*, the western parts of Connecticut, Massachusetts, and Vermont, yet they appear again in considerable abundance on the eastern face of this region. In Rhode Island north and east of Providence occur large areas of limestone, probably belonging to the Lower Coal Measures or the sub-Carboniferous limestone, and in eastern Massachusetts, in the counties of Middlesex and Essex, some small areas of crystalline limestone of Archæan age occur, but not in sufficient quantities to afford a basis for industries. On the coast of Maine we have very important deposits of limestone that afford the basis for the largest industry in lime-making that has been developed within an equal area in the United States; but the physical conditions of the rock do not favor the quarrying of building or ornamental stones at this point.

None of these limestones are well suited for road-making materials, as their distinct crystalline structure causes them to shatter and fall into a powdery state beneath the wheels.

I estimate the area occupied by workable limestones in New England at not exceeding about 500 square miles; in Massachusetts, Rhode Island, and Maine the area is less than 200 square miles.

SANDSTONES AND CONGLOMERATES.

These rocks occupy an area considerably more extensive than that occupied by the limestones; it probably amounts to not less than 800 square miles of surface in all New England, and in Massachusetts, Rhode Island, and Maine includes about 600 square miles of area. The varieties and uses are approximately as follows:

FINE-GRAINED, REDDISH, AND BROWN SANDSTONES.—Used for flagging and the external walls of houses principally the latter.

CONGLOMERATES AND COARSE GRITS.—Used only for external walls.

Of these building stones the first group is very limited in extent, being confined to the immediate vicinity of the Connecticut river, between the northern part of Massachusetts and the mouth of the stream. The greater part of the material is composed of very uniform sand, in which oxide of iron is plentifully mingled. The material, quarries easily and works well under the chisel and the hammer; its endurance to weathering is, however, but slight in the variable climates of the northern United States, yet, on account of the ease with which these stones are worked and their very rich color, they have come into very extensive use in all the eastern cities north of Virginia. There are lighter colored and more flag-like stones of this same series that occur most abundantly in the region near Turner's Falls. These beds have been, at various times, worked for sidewalk flags, yet their use has not been large; it is from the rocks of this age and character that the foot-prints of various amphibians have been so plentifully obtained.

The conglomerates of New England have a very wide extension, but only in a few regions have they been worked to any extent. The only region where an extensive quarrying industry has been based upon them is in the neighborhood of Boston, Massachusetts. They are the building stones most accessible to that city, and so have come into very extensive use for wall work in buildings of a costly character. This stone is extremely durable and of a handsome reddish-yellow or gray color. Owing, however, to the infrequency of the joints in the rock the process of dressing is costly, the stone being perhaps the most expensive of any that has ever come into considerable use in this country. Its peculiar pebbly structure makes it singularly unsuitable for ornamental purposes, as it cannot be worked into any other than a flat surface. Except in Rhode Island, where the inferior carboniferous conglomerate is somewhat used for rough walling, the neighborhood of Boston is the only place where conglomerate has been extensively used for any building purposes; indeed we may say that conglomerates have been more generally used there than in any other city, European or American.

SLATES AND CLAY-STONES.

This group of rocks is very abundantly developed in New England, and has been made the basis of very extensive industries. The area occupied by workable rocks of this class is probably not less than 1,500 square miles in all New England, and perhaps exceeds 700 square miles in the states especially considered in this report. This group of very argillaceous rocks is to be divided into the two classes of slates proper and clay-stones on the basis of the relative fissility of the material given by the joints or cleavage planes. The slates proper are affected by true cleavage, and are almost indefinitely divisible by the cleaving-tools of the quarrymen. The clay-stones have only a jointed structure and are not indefinitely divisible in this fashion. The following are in brief the uses of these two stones:

CLAY-SLATES.—Used for roofing slates, billiard and other table tops; chimney mantels (with or without artificial overfalls); flagging stones, school slates, bath-tubs, wash-tubs, etc.

CLAY-STONES OR ARGILLITES.—Used only for wall work. The geographical distribution of these slates and clay-stones is rather peculiar; they occur in one form or another over all parts of New England, yet the area of the deposits of workable quality is small and widely scattered. Of true slates Massachusetts has no workable deposits that have yet been discovered, and I think it very unlikely that any will be found; none are known in Rhode Island, though it is not impossible that both there and in Connecticut available deposits may yet be found. In Vermont and in Maine there are large areas of good roofing slates, and their development has been the basis of extended industries. The clay-slates have only been occasionally used, principally for road material and rough, dry walls. About Boston there are some quarries that have recently been used as sources of building material for churches and other large edifices. As yet, however, this class of stones has been much neglected. The first quarries in this country, certainly the first in Massachusetts, were opened in stones of this description. These are the quarries in Neponset, formerly Milton. The material was used for grave-stones, mile-stones, and, to a small extent, for flagging. (See second part of this report.)

HIGHLY METAMORPHOSED ROCKS.

Under this head I shall, for convenience, include all those rocks that have lost their original character by fusion or by a very complete metamorphism. The classification has no other merit than convenience. First in importance among these is:

GRANITIC ROCKS.—Used for a great variety of constructive and ornamental work.

SCHISTOSE ROCKS (GNEISS AND MICA SCHIST).—Little used for building save for rough walls. No important industries resting upon them.

TRAPPEAN ROCKS.—Very little used save for road material.

SERPENTINES AND STEATITES (VERD-ANTIQUES AND SOAPSTONES).—Extensively used, particularly the latter, for stoves, chimney-guards, etc.

This group of highly metamorphic rocks makes up the greater part of New England; perhaps three-quarters of its whole surface is composed of them, but the several kinds are found in very different proportions. The granitic group occupies several thousand square miles, and the schistose group an even larger area; the trappean rocks are found almost everywhere in small masses penetrating through the other groups of rocks, while the steatites and serpentines occupy the least area of any of the New England rocks, their whole surface not exceeding a few square miles.

The granitic rocks of workable quality lie principally in the eastern parts of New England, and are found in their best shape along the coast of Rhode Island and the coast-lines of Massachusetts and Maine. They are the cores or centers of old mountain ranges which have been worn down to their very bases, principally by the long-continued action of the sea and the glaciers of the ice times. Some excellent granites and syenites occur also in the New Hampshire district and in central Maine. Although the granitic rocks of Scotland afford some ornamental varieties that are more beautiful than those of New England, I know of no region in the world where this class of rocks can be found in greater abundance or in more workable forms than here. It is possible in several of the syenite quarries of Massachusetts to break a single block from the quarry that shall have a length of 150 feet, a depth of 10 feet, and a width of 30 feet, the whole mass without a flaw.

The schistose rocks of this district, like those in other countries, have few qualities that fit them for any architectural purpose, and the same may be said of the trappean rocks. These old lavas in this district are invariably characterized by the presence of many joints that tend to make them cleave in various directions. These joints are readily opened by the weather, and so the rock crumbles into small polygonal blocks. This material is used only for road material, for which use the ease with which it is fractured and the great hardness of the ultimate masses peculiarly fit it. The large amount of iron oxide it contains also serves to bring about cementation of the macadamized material in the road-bed.

In the serpentines and steatites of New England we have the foundation of some small but interesting industries which promise a very great development in the future. In Massachusetts the most important localities for this class of materials are near the west end of Hoosac tunnel, and in the eastern part of the state between Lynnfield and Newburyport. At both these points a little work has been done in former years, but bad management shipwrecked the works before they obtained any considerable development.

It now remains to notice a class of building materials which has not been considered in the preceding list, viz: The drift or glacial bowlders that abound in New England. If we consider the whole of the existing walls in New England, those used for fencing as well as those in the more important foundation walls of the wooden or masonry buildings of the region, we shall find that at least 95 parts of the whole are composed of this glacial waste. Sometimes the stones, where the work is to be bound with mortar, are riven with wedges so as to give a better face for the attachment of the cement; usually, however, the stones are used without any such precaution. I know of no other district where these rude stones have been of as great service in the rough economic architecture of a country, although this use of glacial pebbles is common in other parts of America and in the glacial districts of Europe, from the lands of Scotland to the valley of the Po.

A GENERAL ACCOUNT OF THE DEVELOPMENT OF THE QUARRY INDUSTRIES OF THE DISTRICT.

Whoever has made himself acquainted with the singularly great variety of the building stones that exist in New England must in the end be surprised at the limited extent to which those resources have been applied to the arts of the country. Although the finest quarries in the country exist within its limits, there are fewer masonry houses in proportion to its wealth and population than in any other region of like extent in the world. By far the larger part of the houses are of wood, and when stone is used, save in the larger cities, it is unwillingly taken as a building material, and is generally brought from a distance, though better sorts may be close at hand. Thus in Cambridge, Massachusetts, a city of 60,000 people and of very considerable wealth, there are but a dozen stone buildings, and none in which the material has been made the basis of any considerable ornamentation. In other words, there is but one stone building to each 5,000 inhabitants. There is not a single dwelling-house of stone, not more than a few hundred of brick, and these generally of a very inferior sort. Despite its considerable cost and perishable nature, timber has remained the principal building material for dwelling-houses and shops. In the university that owns the best edifices of the city, out of about thirty important buildings only five are of stone, the rest being of brick; yet within 10 or 12 miles of the place there are many beautiful building stones, some of which have been known for half a century.

This neglect of stone as a building material may be understood after a little consideration of the history of architecture in New England. The first settlers of this country brought little wealth with them, and a love for architectural effect was the least of their pretensions. Until the rapid development of mechanical industries at the beginning of this century wealth did not begin to accumulate, or the culture to take on a type favorable for the

development of a taste in architecture. During the first two centuries timber was the natural material for construction; it was by far the cheapest material, and required the least skill for its working. Wherever architecture develops, as it had to develop here, in a plentifully-wooded country the first stage of its progress gives us purely wooden edifices. All or nearly all the earliest Christian churches north of the Alps were of timber, and the houses of the common people were of the same material down to the time when timber became scarce. It is the opinion of many students of architecture that the original types of the Greek temples were also built of wood. The continuance of wood as the principal building material in New England was favored by the fact that during the first two centuries after the settlement of this country the people found themselves exposed to earthquakes of considerable severity. Those of 1685, 1727, and 1755 were of such force that, happening at the present day, they would do no small damage to masonry buildings. Many hundred chimneys in Boston were overturned. It is not unlikely that these shocks had some effect in causing the people to adhere more firmly to the old fashion of building. But the conservatism of art, in nothing so manifest as in architecture, will sufficiently explain the retention of ancient methods in the architecture of New England. During the seventeenth and eighteenth centuries there were positively no beginnings made in quarrying industries. The only quarries I have been able to trace back to the eighteenth century are some few of clay-stones near Boston. These were very small, and only furnished a part of the grave-stones, a few lintels, and a few mile-stones. Stones for cellar walls were obtained from the glacial bowlders, which were used either in their natural state or after being riven with wedges. Even down to the time of the Revolutionary war a considerable part of the grave-stones and masonry blocks were still brought from the mother country, probably as ballast in vessels that carried away timber or fish to Europe.

The first New England stones abundantly quarried were the syenites near Boston and the sandstones of the Connecticut valley. These stones began to come into considerable use in the second decade of this century. As yet these kinds of stones, with the various deposits of slate and marble that occur in Vermont and Maine, afford the only quarry materials extensively produced. The advance made in their development has been very great, and is likely to continue for a long time to come. In the present state of wealth and of taste the demand for building stones is taking other directions from those which of old led to the working of the few materials that have been brought in use. The syenites that have hitherto satisfied the needs of simple strength and cheapness in architecture have little variety of color, and an intense hardness that quite unfits them for the ordinary uses of the decorative architect. There is needed a wider range of stones for use in the decorative parts of our buildings, which shall contribute to embellishment in either of two ways: by means of their attractive colors, or by having a constitution that fits them for the use of the carver who may work them into embellishments. In the following pages I propose to call attention to the various sources of supply whence these qualities of stone may be obtained, as far as they have become known to me during the inquiries which have been made during the present census year or in the twenty years during which I have been a student of New England geology. These resources will for convenience be enumerated under the heads of the several states. It should be noted that these lists are not in any regard exhaustive accounts of materials suited for building stones, but only designate varieties and localities as far as they have found a place in my note-books or in those of my assistants, Messrs. Davis, Wolff, and Chase.

RHODE ISLAND.

The only stones of this state that have attracted my attention are the syenites, conglomerates, and limestones. The quarries in the syenites of Westerly are among the best of New England, the excellent quality of the stone being one element of their success, another being the advantageous position that these quarries occupy with reference to New York and other large markets of the sea-coast. On the point of land south of Bristol other syenites occur, distinguished by the amethystine nature of the quartz they contain. They have never been quarried for exportation, but they seem to me to offer a promising field for inquiry. North of Providence there are some crystalline limestones that are extensively worked for lime. Although these limestones have their mass extensively rent by joints, as is the case with all the limestones known to me in New England east of the Connecticut river, they may with proper search disclose some beds sufficiently free from this defect to give building stones, or at least stones suitable for certain particular uses in architecture. This region affords the best promise of such results of any known to me near the Atlantic coast.

The conglomerates of the Coal Measures are extensively developed in Rhode Island, but they have never been to any extent used for building purposes. Although they vary much in the different localities where they appear, they are generally as well fitted for architectural purposes as the similar but more ancient deposits near Boston. These rocks are abundantly exposed near Providence and at various points along the shores of Narragansett bay, whence they could be readily conveyed by ships or barges, or by rail to Boston. They seem to me to invite experiment.

MASSACHUSETTS.

In this state the variety of unused stones is very great. In the group of granite rocks a fair amount of search has been given to the field; yet some classes of this group have been entirely neglected. The blue-gray Quincy syenite having first established its reputation, all subsequent search has been given to the finding of stones...

sufficiently like it to command the same market. This search has been so well rewarded that at half a dozen other points in Massachusetts good syenites of the same grade have been found, while other and handsomer stones have been passed by. These other granitic rocks occur at various points, but I shall only mention one district which seems to me to offer a profitable field for inquiry. In the ranges of hills which lie to the west of Boston, extending from Melrose through Arlington to Dedham, there exists a great variety of reddish and yellowish blotched granites or syenites that have never been quarried, and are only known to me by chance sections. I am satisfied that these stones can be found in workable masses, and, though they want that evenness of grain that makes the Quincy syenites and other similar rocks so easy to work, I believe they can be quarried without undue expense. I am sure that when polished their extremely effective colors will give them a high place among our decorative stones.

In this connection and on the same field I may note the existence of a large area of porphyrites. This field extends from Malden through Saugus and Lynn to Marblehead. These stones are as handsome and as varied in hue as those of the Mediterranean, which have furnished the supply for decorative uses to Europe for two thousand years or more. In fact, they are as handsome as such stones well can be. They have not been quarried, but it is probable that large blocks without many flaws can be obtained. The peculiar hardness of these stones, which has always been an obstacle to their extensive use, is now less of a disadvantage than of old, for the modern appliances for the use of power very much reduce the cost of working such stones. These materials are in excellent positions for working, forming cliffs of considerable height above the sea. At Marblehead neck it is possible at high tide to load the material directly from the quarry into vessels of considerable burden. This class of stones is found nowhere else in the United States in similarly beautiful forms, and nowhere else in the world, so far as my knowledge goes, in such a favorable position for exportation.

In Stoneham there are some deposits of marble that have been the object of several desultory efforts at working at various times in this century. So far all the stone found, though of an admissibly pure white color, is too much cut up by joints to be useful in the arts. Despite these failures I am not without hope that other deposits now covered beneath the mantle of drift that envelops this region may yet be discovered.

In this same section of eastern Massachusetts there is yet another source of building materials that is full of promise. I refer to the extensive deposits of serpentine that lie in the country between Lynnfield and Newburyport. This deposit has long been known to exist, and nearly half a century ago it was worked at one point as a source of supply of material from which Epsom salts were made. This serpentine has never been fairly opened save at one point, in Lynnfield, where a pit 15 feet deep has been sunk into it. From this opening some beautiful blocks of serpentine have been obtained, which show that the rock is well fitted for architectural purposes. Near Newburyport the rock seems to be more divided by joints, but it is of harder and more beautiful texture. Near Lynnfield it appears to be of a softer nature, yet not too soft for the best uses, and the blocks are of larger size than elsewhere. As yet the means of observing this deposit are too limited to afford the basis for exact statements, yet I know in America no other rock of equal promise.

In the vicinity of the east end of the Hoosac tunnel, in close geological relation with the well-known deposits of steatite that occur there, exists an extensive deposit of serpentines in which quarries have never yet been opened. The quality of the polished specimens I have seen seems very good indeed, and the deposit seems well worth a careful investigation.

I may also commend to the consideration of quarrymen the many varieties of clay-slate that occur at various points in Massachusetts, particularly near Boston. These clay-slates have long been worked for road materials, but have not been much used for construction purposes. These stones generally break well in the quarry, and are tolerably well suited for hammer-facing. Their main joint-planes are generally richly colored by iron oxide, which gives them a handsome effect in a wall. The only important edifice that has been constructed of this variety of stone is the Shepherd Memorial church in Cambridge. The cost of quarrying the stone was much less than that required for the Roxbury conglomerate, and when placed in the wall the actual cost was only about one-half as great as the conglomerate in the Mason chapel, a very similar edifice a few yards away. The distance of the buildings from the quarries where the stones were obtained is about the same. The general effect of these stones is nearly alike.

In the neighborhood of Boston there are some trappean rocks that are free from the general objection that must usually be held against New England traps in general, and which are capable of making excellent building stones. I refer to the amygdaloids of the Brighton district. These rocks occupy but a small area, not exceeding about half a square mile, yet they lie well for quarrying, the joint-planes being quite favorable for working. The color is a dark mottled green, which would seem to enliven the architecture of the structures built of the similar colored stones that prevail in this region. In the same series of rocks, apparently also of trappean nature, are some deposits of a lively green color. These are best shown near Newton Upper Falls. They seem to me to promise a useful decorative stone.

In western Massachusetts, although the district lies beyond the limits of the work specially undertaken by the survey, I may notice a few of the most important features connected with the prospective quarry industries. In this section we have none of the free-splitting granitic rocks which are so remarkably abundant in the coast

region of New England. The rocks most like them have a gneissic form that causes them to break irregularly. They were splendidly exhibited in the central portions of the Hoosac tunnel, and their extreme resistance to the action of powder as well as to the drill made that great work very costly. This rock is well exposed at the surface in the district just south of the tunnel in positions favorable for quarrying. Although it is not easy to work in the heading of a drift, such as a tunnel requires, I believe that a skillful and ingenious quarryman would manage to deal with it in an open working. The stone is extremely handsome, having the peculiar banded structure of gneiss, with a semi-opalescent quartz in large crystals. It is exceedingly resistant to transverse pressure, its structure making it, when strained across the fiber, almost as elastic as wood. It should not be used as a decorative stone in any position where it would require dressing, but it is very suitable for long lintels, and I believe it would furnish excellent edge-stones. As some of its faces are smooth it could also be had in forms suitable for rough walls, even in buildings of the highest grade.

At present the American taste is rather opposed to the use of stones that do not show the use of the hammer upon them. This is, however, a mere prejudice, for some of the handsomest structures in the world are built of undressed stones. The city of Florence, in many regards the most beautiful city in Europe, has its finest architectural triumphs built of unhewn stone. The Strozzi and Pitti palaces owe to their rough stones the wonderful dignity that makes them nobler in aspect than thousands of more costly structures. When our builders accept a similar simplicity as the worthy object of their efforts it will open this class of rocks to use.

There are some good white marbles in this section that deserve more attention than has been given to them. They are somewhat worked about North Adams, but are perhaps too much jointed and of too coarse a grain to come into general favor.

After considering all the other resources in the way of building stones that are found in Massachusetts, we come again to the granitic rocks as the most extensive and surest basis of its quarry industry, and until the taste for such stones changes they are sure to be the most valuable of all its rocks.

The principal fields for these stones have already been occupied. The most important of the regions which may be designated are the Milton and Quincy district, the district of Cape Ann, the district of Fitchburg, and that of Fall River. The Milton and Quincy district gave the beginning to the granite industry of New England. Its first success was great, and to this day it has more quarries within a given area than any other district in New England, or perhaps in the United States; yet it was not naturally the best locality in the New England region. As far as the quality of the stone is concerned, it is surpassed by the quarries on Cape Ann and by those in Maine. The stone lies well for working, as it occupies a set of steep-faced hills divided by several valleys of considerable depth. The site is near the sea, with which it is connected by the first railway built in this country, and it is also upon the extensive railway system of the Old Colony railroad. It is thus one of the few granite-quarry districts of New England having the advantages of both methods of transportation. At present the product of this district does not seem to increase as rapidly as that of Cape Ann or that of the Maine coast. The general structure of the stone appears to make the production and shipment of the stone a little more costly than in other regions. There are few large rocks now produced there, the greater part of the work being cemetery monuments and other decorative work.

Cape Ann was the next district opened to work. The quarries at that point give an excellent but little tried sort of stone. The only hinderance has been the absence of good harbors and of satisfactory railway connections. The lack of harbors near the quarries has been met by the construction of breakwaters built from the waste stone, but the provision is yet inadequate, and the cost of new harborage is too great for small capitalists.

South of Boston harbor, in Cohasset and a part of North Scituate, there are excellent sites for quarries. The stone is of a light red color, and works well, but the difficulty of harborage at the quarry point has led to the failure of several experiments in quarry work. At present the land along this shore is so valuable for villa-sites that it is not likely to be used for quarry purposes. The Fitchburg and Fall River districts, as well as the large area of granitic rocks along the line of the Boston and Albany railway, are capable of extensive development. That near Fall River is, however, the only one that is likely to secure cheap water transportation—an absolute need in the case of any new granite district seeking to compete with those already established in New England. So far the Fall River quarries have supplied only the considerable local demand. They seem to me, however, to be the best placed for extensive shipment of any in Massachusetts except those of Cape Ann.

The stone in the district along the line of the Boston and Albany railway is of good quality. It is, however, of a rather gneissoid structure.

Lastly, I may notice the fitness of the abundant glacial pebbles to the construction of more important walls than those to which they have been applied. So far these stones that lie about nearly every New England field have not been much used save for dry walls or fences and for foundations. Their rounded form does not readily lend itself to the mason's use, yet by sizing the stones and using them with a little patient skill it is possible to make a strong and handsome wall from these fragments. The only considerable structure which I know that is made of boulders is a church in the town of Medford. It is a handsome and ornamental structure, and I am told that the walls cost less than if built of any other masonry.

In the valley of the Po, in northern Italy, glacial pebbles of small size, often not exceeding 3 inches in diameter, are extensively used for building. Sometimes a frame-work of timber is first built to take the strain of the roof, and then these pebbles are built in between the timbers. In all New England these stones left by the glacial period are always very enduring, for the reason that the rough handling withstood in their making fully tested their strength. They are often very smooth, and show their natural colors to great advantage. It is to me remarkable that so simple and evident a source of construction stones has been neglected for generations in a region where good, easily-worked materials for masonry are not generally accessible. It is only to be explained by the natural conservatism of architecture, a field of activity where the penalties for rashness are often great and the profit from any one successful experiment is usually very small.

MAINE.

The building stones of this state are less known than those of any other New England state. There has been but little demand for them save for export purposes, and the distance of carriage is so great that but few of the great variety to be found there have ever been brought into use. Along the coast the limestone of Rockland and the neighborhood has long been quarried for lime, and at certain points the excellent syenite that abounds in this region has been quarried for southern markets; but nothing like a search has yet been made for the available building stones of this coast. This region is peculiarly adapted to afford a great variety of building stones. The shore is formed by the extremities of many mountain ridges, which have been planed down by the sea and by glaciers so that they no longer appear as mountains. These old mountains, which are evident only to the geologist, stood at right angles to the shore. This disposition of the rocks causes a singularly great variety of stones to be exposed at the coast-line. The harbors are numerous and deep, so that the products of the quarries can generally be loaded directly into large vessels. These conditions make this region more favorable for the development of a large quarry industry than any other region known to me in this country or in other countries.

It is much to be desired that a careful study of the stones on this coast should be made. In the meantime the following notes which have been gathered during the census, and other studies, may have a certain value as indices of the resources in the way of building stones that may be found there. Beginning at the eastern extremity of the state we may note that in the neighborhood of Calais and thence toward Perry and Eastport there are extensive beds of a very reddish feldspathic rock, probably to be classed with the granites, which deserve far more attention than they have yet received. In the town of Perry and in the towns that border upon it there are some distinctly-bedded rocks that are likely to furnish good flag-stones of fair hardness. The same may be said of the region about the winding shores of the South bay, an extensive sheet of water near Eastport. We find there many beds that would yield good flagging stones. There are some very red conglomerates in this district that might be useful on account of their brilliant colors, but they are too much jointed for the most favorable working.

Passing to the westward from Passamaquoddy bay we are for a great distance principally in granitic rocks. There are, however, many distinctly-bedded rocks of a much metamorphosed character at various points which may afford flag-stones. It is impossible to give particular localities, as the rocks have never been quarried, but the section between Lubec and Doverboro' seems to me the most promising region for search. Between Machiasport and Harrington the granitic rock is the only important material. The stone in this section, like that near Calais, is of a reddish color. Indeed, this seaward face of Washington county is characterized by the reddish tint of its metamorphic rocks, which in turn has given a reddish cast to the slates and conglomerates that have been formed from them. The best of the granites of Washington county are found in these red granites, which are probably all of about the same age. This set of rocks extends far into the interior, but they are so much more available along this shore district that it is not worth while to seek them elsewhere. I am satisfied that when the diverse qualities of these reddish granites have been determined by proper exploration it will be found that this part of Maine will afford a wider variety of these stones than any other district in New England.

Near Addison there are quarries of diabase. These rocks are commonly classed as dark-colored granites, which they somewhat resemble. The principal objection to this block granite for building stone is that in some localities it shows a tendency to decay with great rapidity. A similar stone exists near Boston, in Somerville, Melrose, and Medford, Massachusetts; but, though handsome and easily worked, it is unfit for out-of-door use, as it will often lose color in a few years and fall away in flakes. This objection does not seem to hold against the stone from this part of Maine.

Between Harrington and Gouldsboro' there are excellent exposures of granite of various colors which have not yet been quarried. We next find worked quarries at Sullivan. At this point the granite has a set of cleavages which causes it to break out in long rectangular prisms, a form peculiarly favorable for the quarryman's work. Connected with this easy breakage we have numerous slight veins in the stone that seem to make it break too easily for the best uses, and somewhat affect the color of the blocks. The rather reddish granites outcrop along the coast to the westward. On the shores of Somes sound, a deep inlet that penetrates the island of Mount Desert, there are quarries of a light red granite. Here, as elsewhere along the shore, the best quarries are found in the sides of the hills. As these hills are the parts of the rock that have best resisted erosion, it follows that they are the most solid and enduring of the rocks of the country. It may be said that throughout New England

the thickly-bedded enduring rocks are in the hills, the softer and more thinly bedded in the valleys. It seems never worth while to seek for good granite in the valleys since a slight depression shows some element of weakness that makes the rock unsuitable to the quarryman's use.

Excellent granite quarries exist at the head of Bluehill bay, to the west of Mount Desert. Deer island and Vinal Haven island have exterior quarries of the same stone. On the latter island the stone splits in larger blocks than anywhere else in New England, except perhaps in the quarries of cape Ann.

On the west side of Penobscot bay there are exterior quarries in Thomaston and Saint George, near Richland. West of the Penobscot the quarries are not limited to the coast-line, but some are situated on the Kennebec, at a distance of 60 or 70 miles from the sea. This is not because the granite is particularly better or more abundant there than in the inland region of the Penobscot, but because there is more local demand for stone and the means of shipment by railways are much greater. There are also considerable quarries of roofing slates in this section of the state west of the Penobscot river; they lie, however, much north of the belt of granite quarries. The granitic character of the coast is continued to the New Hampshire line, and the numerous small and a few large quarries attest the general goodness of the stone. It will be noticed that the only building stones quarried along the coast of Maine are granites, or crystalline rocks closely related to them. It must not, however, be supposed that no other kinds of stone occur along this coast. The limitation of the production to this single quality of stone is to be explained in part by the fact that this stone is the only one for which there is an extensive market, and the search has naturally been first made for it. Even more, however, must be attributed to the fact that the continuation of marine and glacial erosion which has gone on upon this shore has worn away almost all the softer rock exposed to its action. The larger part of the limestones, slates, sandstones, etc., that find their geological position on the folds along this coast have been so worn away that they lie beneath the surface of the deep indentations of the sea which are so conspicuous here.

These granitic quarries afford very excellent conditions for working. The stone opens easily, having the peculiar inchoate joints that are such striking features in the syenite or granite of New England. There are generally at least two of these rift-lines. Then there is a more or less complete division by what appear to be true beds, as well as joints, so that the division of the rock is as complete as could be desired. At the same time the lines of weakness in the rock are not so numerous as often to make the quarried masses too small for use, as is sometimes the case in other districts. The impurities in the way of spots and veins, which often seem to mar the appearance of granitic rocks, are not found in any great abundance save at a few points. Added to these advantages this shore affords a frontage in its islands and inlets of not less than 2,000 miles, the larger part of which lies in workable granite or kindred rocks, though of course not always of the best kind.

Although the extreme erosion has left little of the more wearable rocks along the coast-line of Maine, the inland regions seem likely to yield a good variety of stones. The principal trouble at present is that the coating of forest and the layers of drift mask the greater part of the surface, except where the very hardest rocks occur.

MACHINERY AND LABOR.—In the larger New England quarries steam cranes or derricks are generally used to move the stone to the carriage that carries it away from the quarry heading. In the smaller quarries the hand-crane alone is used. These cranes are generally conveniently arranged for their work.

In the latter class of quarries wagons for conveying the stone to the shaping- or dressing-grounds and to the shipping-grounds are no longer employed. The road out of the quarry is generally occupied by a tramway, and locomotives, generally of the light dummy pattern, are used to drag the carriages to the shipping-point or to the dressing-grounds.

From a considerable knowledge of the European quarries I believe that the amount of manual labor used in their quarry work is at least twice as great as that required in the better class of American stone pits. The result is that we can furnish rough stone at a lower price than that at which it can be produced in Europe, despite the higher price of labor here. In the treatment of the stone after it leaves the quarry the American methods show no advance upon those of Europe; and it is in this part of the work of preparing building stones that the cost most rapidly increases. The wages for all sorts of hand-work in dressing are very dear, and so far little effort seems to have been made to replace these methods by mechanical contrivances. When stone is to be dressed into ornamental shapes it does not seem practicable to gain much by any mechanical processes; but when the aim is merely to polish the flat face of the stone or to bush- or face-hammer them, it ought to be possible to replace hand-work by automatic machinery. One reason why more effort has not been made in this direction is doubtless that mechanical power derived from steam is generally costly in the quarrying districts of New England. This may perhaps be met by the use of tidal water-powers that abound along all this coast-line. These water-powers can often be brought into use at a very small cost for plant, and as they do not depend on drought, and generally involve no damages for flowage, they will be much cheaper than fresh-water power. Their general utility is sufficiently proved by the frequent use made of them on this shore for ordinary milling purposes.

TRANSPORTATION.—The carriage of the quarried stones to market is generally effected by rail or water. The quarries near the sea-board have a great advantage over those upon the railways, inasmuch as they can ship at much less cost, the carriage by sailing-vessel being only a small fraction of that which must be charged by railway. On these vessels the stone is generally laden upon the deck, except the smaller sorts, such as paving stones, which are

stored in the hold. It seems to me that vessels of the sort known as catamarans, *i. e.*, those with two distinct bodies, with a pavement covering the whole, would make safer forms of ships for this carriage, as it is the heavy deck burden that makes an ordinary ship very top-heavy and liable to accidents.

GENERAL RELATIONS OF NEW ENGLAND BUILDING STONES TO THE MARKETS OF THE UNITED STATES.

It is worth while to notice the general relations of the New England quarry industries to the rest of the country, as we may thereby gain the basis for a forecast of their future.

A glance at a geological map will show that the rocks that characterize New England are not found in an equally extensive development in any other district south of the Saint Lawrence and east of the Rocky mountains. The same highly-metamorphosed series of rocks is continued in a less extensive way south along the whole chain of the Appalachians as far as northern Alabama; but it leaves the sea-board region at New York, and south of that point is not readily accessible to tide-water navigation. Moreover, when we get even as far south as New York we find that, owing to the progressively less and less considerable development of glacial action in southern regions, the rocks show the effect of decay to a much greater depth than they do in New England, where the last glacial period stripped away all the incoherent decayed portion of the rocks, leaving only that which was well suited to the use of the quarryman. The result is that even near New York, and in a greater degree for every step eastward, the stone is decayed along the joints to such an extent that we can rarely find good solid blocks within from 20 to 50 feet of the present surface. This deep "cap" of decayed rock is a serious hinderance to the development of good quarries of crystalline rocks in a large part of the southern Appalachian mountains.

These two advantages, the neighborhood of the crystalline rocks to the sea and the absence of any worthless decayed upper part, will always give the New England rocks of the granitic group a very great advantage over those of any other part of the eastern United States.

It should also be noticed that the cost of quarrying granite of good quality is perhaps less than that of any other work of the same general utility, certainly much less than the cost of our other principal building stones, so that, for all large structures where rude strength is the only need, quarries of this stone are always likely to be at a great advantage in production.

There are no other sources of supply of granite that are ever likely to compete with this stone district of New England. The same qualities of stone are found in southern Nova Scotia with the same advantages of quarrying; but this region is on the average several hundred miles farther from the principal points of consumption, so that the tax due to distance will always amount to about as much as the present profits of the New England quarries. The cost of carriage on a ton of stone from Nova Scotia above that from cape Ann, supposing the distribution to be to New York or Philadelphia, is at the present low rates of freight about 50 cents. This is probably more than the average profit that is made upon the stone itself. Thus there could be no effective competition save for such stones as have been carved or finished, so that the actual value bears a very large proportion to the original cost of quarrying and conveying to market. It is quite clear, therefore, that the position of the New England granite quarries is particularly favorable, and that they are likely to command the market for cheap stones for a great while in the future.

The same may be said, though in a less emphatic way, for the other building stones of this region. The roofing slates, particularly those of Maine, the exploration for which has hardly begun, are very well placed for marketing, as they have the same advantage, arising from the small amount of waste rock on their surfaces, that the granite quarries have. The slates have rather more drift matter upon them than the granite quarries have for the reason that they generally lie in rather lower ground; still this drift is loose material requiring no other than pick-and-shovel work before the profitable work is attained. In Maine, especially, these quarries lie near enough to tide-water to share the advantages arising from their method of carriage; being not more than from 30 to 60 miles away from the nearest tide-water navigation.

There are no certain supplies of good marble within a remunerative distance of the shore-line of New England, the nearest approach thereto being the extensive deposits of serpentine rocks that lie in Middlesex and Essex counties, Massachusetts. Between Lynnfield and Newburyport there is an extensive deposit of this character that will afford a material suitable for the carver's art.

I am not without hope that it will be possible to find some marbles suitable for building purposes in Rhode Island or in Maine, and it is greatly to be desired in the interests of American architecture that more good carving stones should be brought into market. Though New England abounds with excellent and beautiful construction stones, it leaves much to be desired in the way of stones fitted for the work of the sculptor. None of its marble is really fit for the best statuary purposes.

DETAILS REGARDING QUARRIES.

MAINE.

[Compiled mainly from notes of John Eliot Wolff.]

The Red Beach granite quarried near Red Beach, Jonesboro', and Calais, Washington county, is used principally for monuments, and to some extent for general building purposes. It is quite largely used for polished columns. The principal markets are Boston, Providence, New York city, Baltimore, Philadelphia, Buffalo; Cincinnati, Cleveland, Zanesville, and Columbus, Ohio; Springfield and Chicago, Illinois; Milwaukee, Saint Louis, Saint Joseph, Kansas City; Charleston, South Carolina; Wheeling, West Virginia; Washington, District of Columbia, and San Francisco.

In the Red Beach quarries there are two sets of principal joints, both nearly vertical, which seem to be continuous through the granite of this region. The finest set has a direction S. 55° W., and the other 65° E. There are also some less regular cut-off joints running S. 60° W. and slanting east. The sheets are fairly regular, running from 7 to 4 feet and less; the jointing is remarkably regular for granite, and the almost rectangular intersection of the vertical joints gives the blocks a cubical and rectangular form rare in granite. The stone is free from blemishes as seen in the quarry. Little quartz veins and black concretions (one of which when tested appeared to be principally magnetite of small size) are the principal ones. The rift of the stone is parallel to the S. 65° E. joints. On the surface rock this stone weathers with a snow-white appearance. The feldspar, both red and dirty white in color, turns to a dazzling white, the quartz remaining unaltered, while the mica and magnetite and other minerals become inconspicuous. The granite-workers here are very largely Aberdeen Scotchmen, and some of the polishing-machines are adapted from Scotch models.

The stone compares very favorably in appearance with the Peterhead Scotch granite and the Nova Scotia red granite. The rock is a biotite granite, is a good working stone, and quite hard and brittle, taking a high polish. Blocks 7 by 7 by 2 feet thick have been shipped, and blocks 30 by 15 by 2½ feet might be quarried.

The columns of the court-house at Providence, Rhode Island, and those of the custom-house at Kansas City, Missouri, the Centennial block at Portland, Maine, and a portion of the basement of the custom-house at Fall River, Massachusetts, are of this stone.

At Jonesboro' the quarries are shallow and extend over a comparatively broad area on the top of the hill on which the quarries are situated. The sheets thin out, but deepen on going downward. There seems to be but one good set of joints, standing nearly vertical and running north about 80° east. The rift of the stone does not seem to have a very determinate direction, but approximates to a parallel with these joints. The grain is horizontal, the sheets become thicker at the bottom of the quarry, and run from 5 to 3 feet and less in thickness. The stone splits well and straight in any direction, and by drilling and wedging rectangular blocks are obtained. Both light and dark patches appear in the stone.

The greatest defect of the stone, which causes considerable "grout", is the frequent occurrence of red stripes or veins of red feldspar crossing the stone. Some of these stripes appear to be small, very tight seams, along which the stones have become sappy, giving the red color. Veins or dikes of fine red granite run through the quarry in one or two places; often the tongues running out from them are red on the outside and white inside, resembling the patches in appearance. This belt of red granite is locally thought to be continuous with that found at Red Beach, on the eastern edge of the county, and also to cross into New Brunswick and form the Macadare red granite, becoming redder toward the east. Wellington Brothers' building, Boston, and the Hunnewell building, New York city, are among the buildings in the construction of which the Jonesboro' red granite was used.

The trap dikes in Washington county, furnishing white and black granite, properly a diabase or olivine diabase, are quarried chiefly for monumental purposes and shipped to New York city, Brooklyn, Boston, Washington, Montreal, and Quebec. It was used to some extent in the construction of the inclosure-walls of the Capitol grounds, Washington city, for a bank in Montreal, and extensively for monumental purposes in Greenwood cemetery, Brooklyn. Blocks 16 by 10 by 20 feet have been moved in the quarries, and natural blocks 90 by 10 by 15 feet occur. Six miles southeast from Madison point, on Pleasant river, one of the principal quarries in this rock is located; it is a remarkably favorable location, being at the water's edge, and the waste is easily used in extending the wharf. The stone is extremely hard and takes a good polish. The principal defects causing the waste stone are the so-called "knots", consisting of irregular patches of very coarse, white feldspar, mixed with fine, large, black hornblende crystals; little seams also occasionally split off part of a block, but the stone usually presents a uniform surface, free from the frequent patches and other irregularities of ordinary granite. The stone seems to weather remarkably well for one containing so much hornblende. This quarry is called by the quarrymen a "block quarry"—that is to say, the horizontal or concentric sheets of ordinary granite are few. There are two sets of vertical sheets, the best run due east and west and give blocks, as far as the quarry has been developed, from 15 feet down in length. There are also north and south vertical joints less perfect, but more frequent than the others. The rift or easiest splitting direction runs parallel to the east and west joints; the grain, or next easiest, north and south, while the lift or horizontal splitting is hardest of all. Hence the natural blocks are approximately rectangular in shape.

Near West Sullivan, Hancock county, a light gray biotite granite, sometimes having a pinkish tint, is quarried for general building purposes, for paving and curbing, and is employed to some extent for monuments. The principal markets thus far have been Boston, New York, Brooklyn, Albany, Philadelphia, Washington, and other places on the Atlantic coast accessible by water transportation. Blocks 25 by 25 by 2 feet thick have been quarried; the sheets of stone vary from 6 to 3 feet in thickness and have a slight dip to the north. The rift of the stone is, as the quarrymen express it, "on the lift," that is, horizontal or parallel to the sheets, and this is usually the case in the Sullivan granite region. The grain is vertical, running S. 70° E., and has a remarkably straight and plane cleavage, so that the stone frequently comes out in long rectangular prisms. It may be said here that these beautiful cleavages are among the characteristics of the Sullivan granite and are of great advantage in making paving blocks, as the blocks are shaped from the material with ease, a few slight blows often sufficing to reduce the stone to a proper shape. There are also vertical joints running across the grain S. 20° W. The principal defects are the black patches, and some of the stones have very thin seams called by the workmen "pencil-mark" seams, from their appearance; these are an element of weakness.

A mile north of West Sullivan is located a typical sheet quarry, the sheets running from 2 to 6 feet in thickness, having a very smooth almost plain though gently-curved surface, dipping slightly to the northwest. Vertical joints are few. The rift is on the lift, or parallel to the sheets, and the grain is vertical. There are some large vertical joints running through the quarry; some of the quarrymen distinguish seams running across the grain obliquely as "grain" seams; seams oblique to the grain as "tight" seams, and certain seams coated with decomposed feldspar as "chalk" seams. There are several very large black inclusions seen in the granite.

A quarry producing excellent splitting stock is situated three-quarters of a mile north of Sullivan. The sheets run from 7 down to 3 feet in thickness. There are some large vertical joints running northeast occasionally filled with trap dikes. The stone has a somewhat conchoidal fracture and shows the usual black patches. The rift is parallel to the sheets, and the grain runs east and west at right angles with the vertical jointing.

Near Franklin, Hancock county, a light gray, massive, biotite granite is quarried for curbing, paving, and cemetery work. The principal markets are Boston and New York city. The texture of the stone is medium fine and porphyritic. Blocks 30 by 14 by 3½ feet thick have been quarried.

On Somes sound, 2½ miles south of Somesville, Mount Desert island, Hancock county, a light gray, massive, biotite granite is quarried for general building purposes, bridge construction, and paving. The stone was used in the construction of the Brooklyn approaches and towers to the East River bridge, and in the arches and foundations, and the new bridges in Back Bay park, Boston. Blocks 150 by 50 by 18 feet thick have been loosened in the quarry. The position of the quarries on Mount Desert island is peculiarly good for shipping, as they lie near the head of Somes sound along a narrow and very deep fiord, running several miles inland from the southwest harbor, between the mountains. One of the quarries is situated on the side of a hill and at the water's edge. The sheets of stone are very thick in some cases, one being 18 feet in thickness. The sheets have a steep dip from the summit of the hill down to the water's edge. There are a few north and south vertical joints or headings, usually not less than 60 feet apart. The rift is on the lift of the sheets, and the grain as usual is parallel to the great north and south joints. In connection with the dip of the sheets away from the hill, considerations concerning the form of the granite hills of New England suggest themselves. It is held by some that these hills have been rounded into their present shape by ice, while others believe that their form is due to the structure of the granite.

In Maine not only are the quarries of great extent and depth, and generally located on hills, but these are generally sufficiently bare of vegetation to conceal the outline. Many of the larger quarries of Maine are sheet quarries, and in every case where vertical joints are not present, breaking up the sheets to such an extent as to conceal their direction, the round form of the hill is plainly seen to be due to the gentle curve of the sheets.

Two miles south of Somesville there is a granite quarry, the opening of which is yet shallow, and the sheets are consequently thin. The rift is on the lift and the grain is approximately east and west; the infrequent joints are mostly north and south.

Near East Bluehill, Hancock county, a light gray, sometimes pinkish-gray, massive, biotite granite is extensively quarried for general building purposes and for paving. It has been used in the construction of the city hall (trimmings), the art gallery in Fairmount park, and the Pennsylvania Railroad bridge, Philadelphia; in the East River bridge, New York city; the post-offices in Chicago and in Harrisburg; and the Thomas monument in Washington city. In texture the stone is medium-fine porphyritic. Blocks 90 by 80 by 6 feet have been moved in the quarry; a block of 80 tons was loosened and moved out some feet in one of the quarries. It is a compact, good, safe, and free-working stone, and takes a good polish. Specimens were tested at the centennial exhibition at Philadelphia which showed a crushing resistance of 108,000 pounds to a 2-inch cube. The quarrying here has been to a considerable extent done on the surface, although there are some large openings. The stone lies in sheets, often irregular, from 3 to 10 feet in thickness, and the jointing is sometimes irregular in many of the openings. In one of the quarries there are sheets 9 feet in thickness, though the usual thickness is from 4 to 5 feet. The stone contains a few black patches, the joints are not frequent, and their direction when present is east and west.

In another quarry the sheets are from 6 to 8 feet in thickness, the dip steeply southeast; the rift is east and west with the dip of the sheets, and the grain north and south. The vertical jointing is irregular; patches and occasional veins of white granite are present. At another opening the sheets reach a thickness of 20 feet; the long seams cut down through the mass, but are usually far apart.

Near Deer island, Hancock county, a light gray, indistinctly-laminated biotite granite is quarried for general building purposes, bridge construction, and paving. It has been used in the construction of the Broadway bridge, South Boston; base of columns of elevated railroads in Brooklyn; and grain elevator of the New York Central railroad, New York city. Blocks 14 by 8 by 20 feet have been loosened in the quarries, and the dimensions of some of the natural blocks are as much as 150 by 15 by 15 feet. It is a compact, good, safe, and free-working stone, and takes a good polish. The sheets in one of the quarries reach a thickness of 18 feet, though the usual thickness is from 6 to 12 feet. They extend into the hill nearly horizontally, and are intersected by occasional vertical joints. The rift here is vertical, running north and south, parallel to the joint; the grain at right angles, or east and west.

In another opening the stone lies in very thick and broad sheets, nearly horizontal, with a slight dip toward the water; the sheets are from 6 feet downward in thickness, and are intersected by a few joints. The rift here runs north and south, and most frequent vertical joints also run north and south.

Another quarry in this vicinity lies in a steep hill, the slope running down to the water's edge. Where they are now working the sheets average 3 feet in thickness, the maximum being 5 feet and the minimum 1 foot. The dip is very steep from the top of the hill to the water's edge. There are few vertical joints; the rift runs best toward the top of the hill. At the north end of the quarry the sheets are horizontal, of great thickness, one being over 20 feet thick, and having considerable length and width as well.

In another of the principal quarries the sheets occasionally reach a thickness of 20 feet; the vertical joints have an east and west direction, and are found at intervals varying from 5 to 60 feet.

A mile and a half south of Frankfort, Waldo county, a gray, massive biotite granite is quarried for general building purposes, bridge construction, monuments, paving, and polished columns. It is sent as far as Mobile and New Orleans. It was used in the construction of East River bridge, New York; basement of the State, War, and Navy building, Washington city; art gallery at the centennial exhibition, Philadelphia; art museum, Central park, New York city; Saint Louis bridge across the Mississippi river; pedestal of the statue of Admiral Farragut, Washington city; forts Knox, Popham, George, Preble, Schuyler, Constitution, and other fortifications. The texture of the stone is coarse and porphyritic. Blocks 80 by 40 by 20 feet have been moved; a block of 30 tons was cut and shipped. It is estimated that blocks 150 by 50 by 12 feet might be moved in the quarry. The principal quarry is situated on mount Waldo, overlooking the Penobscot river, and at an elevation of some 320 feet above high tide. It is a situation allowing of easy disposition of the waste; the stone lies in immense sheets dipping off from the mountain, varying in thickness from 1 foot to 20 feet, the usual thickness being from 4 to 5 feet. The quarry is traversed by frequent head joints running S. 75° E., but there are comparatively few joints at 90°.

The rift is on the lift, or parallel to the sheets; the grain runs S. 75° E., or parallel to the headings. Two varieties of stone are obtained—coarse and fine; the local impression is that a belt of fine granite runs through the coarse prevailing granite. This stone was used in the construction of many of the eastern forts before the late war, but a year or so of the war demonstrated the comparative inferiority of stone for this purpose and caused the building of stone forts on the Atlantic coast to be discontinued, and the business of several of the Maine quarries was for a while diminished through this cause.

Near Prospect, Waldo county, a gray, massive biotite granite is quarried to a limited extent for street work, basin heads, platforms, and bridge construction. It was used in the construction of the railroad bridge at Bangor, and in the East Boston dock. The texture of the material is rather coarse; the stone lies in sheets, and the rift is on the lift; there are two sets of joints. Blocks 6 by 4 by 4 feet have been shipped, and blocks 30 by 35 by 10 feet might be moved in the quarry.

Near Swanville, Waldo county, gray biotite granite is quarried for cemetery work, paving, platforms, and columns. The principal markets are New York city, and Boston and Quincy, Massachusetts. It was used in the construction of a soldiers' monument at Buffalo, New York. Blocks 20 by 9 feet by 1 foot and 10 by 10 by 2 feet have been cut, and blocks 40 by 20 by 2 feet might be moved. The stone here is uniform in texture, free from blemishes, and is a compact, good, safe, and free-working stone, taking good polish, and lies in regular sheets varying in thickness from 1 foot to 4 feet. The quarry is located on a hill, and has not as yet been developed to any great depth. The rift is vertical, and runs north and south, the grain east and west; the vertical joints cut through the quarry east and west parallel to the grain.

At Lincolnville, Waldo county, about 6 miles west of Camden, a very light gray, massive muscovite-biotite granite is quarried to a limited extent for underpinnings and local stone-work generally. Thus far it has been used only in Camden and vicinity. Blocks 12 by 2 by 6 feet have been quarried; blocks 50 by 25 by 6 feet might be moved. This stone has a good appearance, is uniform in texture, and is a good, safe, and free-working stone, taking good polish. It does not lie in sheets, but rather in blocks. There are frequent vertical joints in one direction. The rift is vertical and about parallel to the vertical joints. The quarry lies near the base of a mountain near Camden, but it is small and not worked regularly.

The extensive quarries at Vinal Haven, in Knox county, produce granite for general building purposes, monuments, and paving. It was used in the construction of the East River bridge; half of the Masonic temple, Philadelphia; Sailors' Snug Harbor, Staten island; half of the railroad bridge at Saint Louis; basement of the State, War, and Navy departments, Washington; custom-house and post-office, Cincinnati; polished work in Chicago court-house and city buildings; part of polished work in Philadelphia city buildings; a portion of the basement and quadrangle of the Patent Office building, Washington city; the Butler monument at Greenwood Cemetery mausoleum; and smaller monuments in various parts of the country. The color of the predominating material in these quarries is light gray; the texture is medium coarse. There is a dike of trap in one of these quarries, producing what is locally called "black granite", and used to some extent for building material. In what is known as the Harbor quarry the rift is very good, and is vertical, having a direction east and west; there is a very frequent vertical jointing in this same direction, giving long, narrow blocks; north and south joints are less frequent. The sheets vary from 3 to 8 feet in thickness, and immense masses of stone entirely free from joints occur.

The Sands quarry, adjoining the Harbor quarry, is bounded by two sets of great vertical head joints, running respectively northwest and southeast; and the easiest rift is vertical, parallel to these joints. In the center of the quarry there are not many joints; the sheets average from 4 to 5 feet in thickness, but some are 7 and 8 feet thick; they have a slight dip west, with quite smooth surfaces. The obelisk sent from this quarry to serve as a monument to General Wool, at Troy, New York, is said to be the largest quarried in modern times. Its dimensions are 60 by 5 by 5½ feet. Four long blocks were quarried before a satisfactory one was obtained; one of these lies on exhibition near the quarry. Natural blocks 240 by 32 by 8 feet can be seen in the quarries. Occasional black micaceous patches occur in the stone, which, together with vertical dikes of light-colored stone, constitute the principal defects seen. The East Boston quarry is a sheet quarry of fine-grained stone, the sheets running from 2 feet downward, and dipping slightly east. The rift is horizontal; some long east and west head joints traverse the quarry, but between these the jointing is irregular. The stone has been most used for paving and platforms.

In a quarry at Duschane there are vertical joints running regularly through the quarry at intervals of from 5 to 10 feet, in an east and west direction, and, as the grain of the stone or next easiest rift runs north and south, the blocks come out in rectangular shape. The rift is vertical and parallel to the east and west joints. The hardest splitting direction is on the lift, or parallel to the sheets, and the sheets are irregular. In one case the vertical thickness is 12 feet. The material has a pleasing appearance and is now used for polished work.

In the town of Vinal Haven there is a very small granite quarry, in which the structure of the stone is such as to be a very convenient source of paving material. The stone is extremely good, occurring in regular sheets of from 1 foot to 3 feet in thickness and nearly horizontal. There are occasional black patches; some long east and west vertical head joints bound the quarry, and there are also a few north and south joints. The peculiarity of the stone is its beautiful and even rift, and paving blocks may be shaped from it by a few blows of the hammer.

At Hurricane island, three miles southwest of Vinal Haven, a dark gray granite, sometimes having a pinkish tint, is quarried for ordinary building purposes, monuments, columns, and paving, and has about the same markets as the other Vinal Haven quarries. The stone was used in the construction of the following buildings: All the superstructure of the new post-office and custom-house, Saint Louis; the basement of the new city hall, Providence, Rhode Island; superstructure of the post-office at Fall River, Massachusetts; polished columns of the Chicago city hall and court-house; portion of the Indiana state-house, Indianapolis; Douglas' tomb, Chicago, and numerous monuments at Saint Louis. The structure of the stone differs in different parts of the quarry. In one portion it lies in comparatively thin sheets, while in another there occur immense masses of solid stone extending 50 feet downward without any perceptible jointing. A block of 80 tons has been moved, and a shaft was produced 23 feet 6 inches by 3 by 3 feet, when dressed, and a mass 80 by 40 by 25 feet was loosened in the quarry, and natural blocks 500 feet long, 20 feet wide, and 50 feet deep occur. The east rift runs east and west, while the grain or next easiest splitting direction is horizontal. The principal joints run east and west, but there are occasional north and south joints.

Three miles north by west from Vinal Haven granite similar in appearance to the Hurricane Island granite is quarried for similar purposes. It is used to some extent in the construction of the Brooklyn bridge, Chicago post-office, and the Raymond jail, in Brooklyn. It is a very superior sheet quarry; the stone lies in very smooth, slightly-curved sheets, having a thickness from 5 feet downward, averaging 3 feet. The sheets have a gentle dip to the west, or toward the water. Vertical joints are found in either direction, and the sheets are smooth, so that the stone is eminently fitted for large platforms. The rift is on the lift; the principal defects are patches, which occur occasionally.

At Muscle Ridge plantation, Dix island, Knox county, a dark gray granite was, until recently, quarried for general building purposes and ornamental work, but the quarry is not at present operated. Among the buildings in the construction of which this stone was used are the New York post-office and custom-house, docks at Castle Garden, and retaining-walls for basin and barge office, New York city; Densmore fort, Hyde Park, New York; Philadelphia post-office; Treasury building (extensions), Washington city; and basement of custom-house, Charleston, South Carolina. Nearly the whole of Dix island has been quarried over, large bluffs having been entirely removed, and

deep excavations contain over 50 feet of water. The rift of the granite here is on the lift, the jointing irregular. Blocks 17 by 17 feet, and of varying thickness, sometimes weighing as much as 72 tons, have been quarried; natural blocks 25 by 25 by 15 feet may be seen in the quarries. The stone is coarse, porphyritic, and indistinctly laminated or massive. Specimens dressed at the National Museum proved to be of more than usual hardness and took a good polish. Steam-drills are employed in the quarrying.

At South Thomaston, Knox county, at Spruce Head island, 8 miles from Rockland, a dark gray granite is quarried for general building purposes, bridge construction, and for monumental work in the cities throughout the country. Among the structures in which this stone has been used are the Albany, New York, post-office (first story); post-office and court-house at Atlanta, Georgia; forts at Portland, Maine; in the East River bridge, New York, and in the Philadelphia city buildings.

One of these quarries at Spruce Head, known as the Bodwell quarry, which has furnished so much building stone to the coast of New England, is in the form of an excavation, commenced at the water's edge and pushed far into the hill, where it reaches a great depth. It is a sheet-quarry, the sheets increasing in thickness downward, and the thickest ones now exposed are from 9 to 10 feet in thickness, and show superb masses of stone. The sheets incline slightly away from the hill with gently-undulating surfaces. There are few vertical joints, almost the only ones having a north and south direction, and the east and west headings run through the quarry, forming the boundaries on some sides. The rift of the stone is vertical, and east and west, nearly parallel to the head joints. The Spruce Head granite has established a good reputation for its quality of resisting weather exposure and retaining its color. The greatest defects have been the black patches which are conspicuous on a bushed surface. There seem to be fewer of these patches in the present deep sheets.

The Sawyer quarry, adjoining the preceding, is similar. The stone lies in very regular and nearly horizontal sheets, varying from 3 to 12 feet in thickness. There are few vertical joints; but there are two sets of large head joints running respectively north and south and east and west. The rift here is reported as being horizontal, or on the lift, which, if true, is remarkable, since it is vertical in the quarry immediately adjoining.

In the Jameson quarry the stone lies rather irregularly in sheets. There are nearly vertical north and south joints; also east and west seams, to which the rift is parallel. The stone has very few blemishes, and specimens dressed at the National Museum were compact, safe, and free-working stones, taking a good polish. The quarry is drained by means of steam-power, and steam polishers are used in dressing.

Near Saint George, Knox county, there are granite quarries extensively operated for general building purposes, monuments, columns, and paving. The following are among the structures in which the stone has been used: Buffalo city hall; United States custom-house and post-office, Hartford; national bank, Albany; government storehouse at League Island navy-yard, Philadelphia; entrance to Chicago post-office; entrances to Utica, New York, post-office; Albany post-office and custom-house (above the first story); McClintock's building (trimmings), Pittsburgh; pedestal of the La Fayette monument, Union square, New York city; post-office and custom-house at Portland, Maine. This stone is of comparatively fine texture and is sometimes indistinctly laminated. It is a free and safe working stone, taking a good polish. Blocks 30 by 12 by 8 feet have been loosened and moved in the quarry, and natural blocks 75 by 60 by 6 feet exist.

Of the three principal quarries the Long Cove quarry has large parallel joints traversing it S. 70° E. from top to bottom at intervals of from 1 foot to 20 feet, and there are sheets of greater or less depth, so that natural blocks have a somewhat rectangular form. The grain is parallel with these joints. The hoisting is done by steam, dressing by hand, and steam polishing-machines are used in dressing.

In the Clark's Island quarry the arrangement of the stone is in sheets from 6 inches to 15 feet in thickness. The sheets have a gentle and sometimes slightly irregular dip toward the water and away from the crest of the hill. The easiest splitting directions are horizontal and parallel to perfectly vertical joints, which traverse the quarry at intervals of 6 feet and upward.

In the Wild Cat quarry the sheets are thin and rather irregular. There are south and east vertical joints, and the rift is parallel to them.

Four miles east of Saint George there is a quarry which was opened in 1879. Blocks 20 by 10 by 7 feet have been moved in the quarry, and natural blocks about 90 by 30 by 6 feet exist. The granite in the Saint George quarries varies from a light gray biotite granite to a hornblende-biotite granite, which is usually darker in color than the other. Hoisting is done by steam, and cutters, polishing-machines, and circular saws are used in dressing.

One and a half miles west of Waldoboro' is a small quarry the product of which has been used in small quantities in the neighboring towns for underpinnings, steps, posts, bases, and to a limited extent for cemetery work. The stone lies in moderately regular sheets varying from 2½ to 7 feet in thickness. The rift is horizontal and the grain runs northwest. The quarry is quite free from vertical joints and could be made to yield large masses of stone. Blocks 40 by 10 by 4 feet have been loosened, and blocks of perhaps 100 by 30 by 3 feet exist in the quarry. The stone is a fine-grained, indistinctly-laminated biotite granite.

At Jefferson, Lincoln county, 9 miles north of Butter Neck bridge, on the Knox and Lincoln railroad, there is a quarry operated to a limited extent chiefly for monuments and cemetery work. The dressing and polishing of the stone are done at Waldoboro', by water-power, and the material is transported to this place by water. Although

called granite commercially, it is more properly a muscovite-biotite gneiss, of a light gray color and fine in texture. Blocks 10 by 20 by 2 feet have been quarried, and natural blocks as large as 20 by 10 by 2 feet are found in the quarry.

Half a mile east of Round Pond and 9 miles south of Damariscotta, Lincoln county, granite is extensively quarried for monumental and for building purposes. Among the structures in which the stone was used are the Seventh Regiment armory, New York city, and several monuments to Admiral Parrott in New Hampshire. The stone in this quarry for 20 feet down is much broken by joints and sheets from 1 foot to 2 feet in thickness. There are frequent vertical joints having a southwest direction, and others at right angles with these occur, but are less frequent, and the grain of the stone is parallel to them. The rift is on the lift, or horizontal. A large dike crosses the quarry parallel to the southwest joints, and large veins of granite coarser in texture than the predominating material occur. The most common rock of this region is gneiss, which outcrops in straight parallel lines after the manner of roofing slate. The gneiss is very curiously interbanded with a massive or gneissoid granite. This is illustrated in the quarry where bands of contorted gneiss, worthless for building purposes, run to the surface at a steep angle in the massive granite quarried. The quarry is so broken up by the irregular sheet-joints and mineralogical accidents that the waste of stone has been very great, and but few large blocks can be quarried at present. The dimensions of the largest block quarried here are 15 by 2 by 2 feet, but blocks about 6 by 6 feet by 1 foot 6 inches may now occasionally be obtained. The material is a dark gray biotite granite, and is a compact, free-working stone, taking a good polish.

Near Augusta, Kennebec county, granite is quarried largely for local use, but some is shipped to New York, Brooklyn, Philadelphia, Boston, and Chicago. The following are some of the structures in which it has been used: The United States arsenal, Cony academy, and a Unitarian church in Augusta, and the Old South church in Hallowell; Mills' building, corner Broadway and Exchange street, and a monument to Recorder Hackett, New York city; Roberts' tomb in Woodlawn cemetery, Long Island; Wood's tomb, Greenwood cemetery, New York. The material is a gray muscovite-biotite granite, massive and of fine texture, is a compact, safe, and free-working stone, and takes a good polish. Blocks 40 by 9 by 2½ feet have been loosened; blocks 20 by 2½ by 2½ feet have been dressed and shipped, and natural blocks 100 by 30 by 7 feet are found in the quarry.

In a quarry 2 miles west of Augusta the stone lies in sheets from 9 feet in thickness downward; east and west head joints traverse it, and the rift is horizontal.

In a quarry 1 mile west of Augusta the rift is on the lift, the grain vertical, having a northwest direction, and the material lies in very regular sheets, usually not over 2½ feet in thickness.

Half a mile to the eastward of this the stone resembles that at Hallowell, and lies in sheets of 1 foot in thickness, with northwest vertical joints.

Near Hallowell, Kennebec county, is a well-known quarry, producing granite very extensively for monuments, columns, trimmings, and general building purposes. Among the structures in which this stone was used are the new capitol, Albany, New York; the Bank of Northern Liberties, Philadelphia; the state capitol and Allen block, Augusta, and the Emery block, Portland, Maine; Odd Fellows' Memorial hall, Equitable building, and part of the old Quincy market, Boston; Ludlow Street jail, the *Tribune* building, and the old Tombs prison, New York city; the statues of the Pilgrims' monument, Plymouth, Massachusetts, said to be the largest statues in the country; the soldiers' and sailors' monument, Boston, and soldiers' monuments at Marblehead, Massachusetts, Portsmouth, Ohio, and Augusta, Boothbay, and Gardiner, Maine; Odd Fellows' monument, Mount Hope, Boston; monuments to General Stedman, Hartford, Connecticut, and Stephen A. Douglas, Chicago, Illinois; the Riley monument, Buffalo, New York; Cowan monument, Lewiston; Allen Lombard monument, Augusta; Lyman Nichols' monument, Auburn; Swazey monument, Bucksport; Mitchell monument, Gardiner; Fuller monument, Hallowell, and Meady pedestal and statue, Pittston, Maine; Tenney monument, Methuen, Massachusetts; Washington Artillery monument and Hernandez tomb, New Orleans, Louisiana.

In this quarry there is no sap on the sheets, or at most a very thin film; there are few vertical joints, and the surface of the sheets is smooth and level, while the stone is remarkably free from black patches, those occurring in the quarry becoming smaller in going down. The sheets increase in thickness downward, and are about 1 foot at the top and 10 feet in thickness at 50 feet from the surface. The sheets have a gentle dip to the north. At certain intervals there occur long vertical joints or headings cutting vertically down through the quarry, having an east and west direction, but north and south joints are rare. There are occasional quartz masses in the stone. The rift is horizontal; the grain east and west or parallel to the main seams. Sheets having level surfaces 36 by 34 by 9 feet deep have been loosened, and natural blocks about 200 by 40 by 9 feet deep are found in the quarry. The material is white or rather very light gray muscovite-biotite granite, and is often indistinctly laminated.

At Wayne, Kennebec county, a coarse, massive biotite granite is quarried to a limited extent for cemetery and general building purposes. The market is local only, the stone being used chiefly at Lewiston and Auburn. It was used in the construction of the Free-Will church, Continental mills, and county buildings, Lewiston. The jointing is irregular. Blocks 12 by 12 by 10 feet have been moved, and there are natural blocks about 40 by 15 by 10 feet. It is a safe, free-working stone, and takes a good polish.

Near Canaan, Kennebec county, granite is quarried to a limited extent for underpinnings, and is used chiefly at Waterville, Canaan, and Skowhegan, Maine, and at Newport and vicinity. The underpinnings of the churches in Skowhegan are of this material. The stone lies in very regular sheets from 1 foot to 2 feet in thickness. There is a very convenient rift, but there are many patches. It is a dark gray biotite granite, rather coarse in texture and indistinctly laminated. It is a safe and free-working stone, taking a good polish.

Near Norridgewock, Somerset county, there are quarries producing granite extensively for general building purposes, foundations, and monuments, and to some extent for polished work. Among the buildings in the construction of which the material was used are the following: Stone-work of the Goff block, Auburn; Dunn block, factory, and bank in Waterville; residence of Captain Holland, Lewiston; Coburn hall, Skowhegan; High Street church, Skowhegan; business block in Dexter, and Langley's monument, Lewiston. The principal quarry lies on the top of a hill; the stone is in sheets of from 2 to 4 feet in thickness. The main seams have an east and west direction, and north and south seams are rare. The rift is horizontal. Blocks 30 by 25 by 7 feet have been loosened in the quarry, and natural blocks 150 by 12 by 4 feet can be seen.

At North Jay, Franklin county, granite is quarried for general building purposes and for railroad construction. It has been used in the construction of factories in Lewiston, chiefly for trimmings, and by the Maine Central railroad. It lies in sheets generally quite thin, from 1 foot to 2 feet in thickness, but the excavations thus far are not deep enough to display the jointing very well. The stone is a fine gray muscovite-biotite granite. Blocks 10 by 4 feet by 16 inches have been cut, and blocks 70 by 12 feet by 6 inches have been loosened in the quarry. The stone works well and takes a good polish.

Four miles east of Chesterville, Franklin county, granite is quarried to a very limited extent, chiefly for underpinning, and is used locally. The underpinnings of some of the houses in Farmington are of this stone. It is medium fine-grained, and occasionally porphyritic, indistinctly laminated, lies in very regular, smooth sheets, and varies from 1 foot to 5 feet in thickness; long east and west joints traverse the quarry at intervals; other joints are very rare; the rift is horizontal and remarkably good. There are few patches, but quartz and feldspar veins disfigure the stone to some extent. It is a good working stone, splits readily in the direction of the lamination, and takes a good polish. Blocks 20 by 3 by 4 feet have been moved, and natural blocks about 100 by 35 by 5 feet are found in the quarry.

Three-quarters of a mile east of Bryant's Pond station, on the Grand Trunk railway, in Oxford county, there is a quarry operated by the railroad for its own construction. It was used in the construction of the Bacon Falls bridge near West Paris. The stone lies in rather irregular sheets, generally from 2 to 4 feet in thickness; there are frequent joints having an east and west direction, and dikes parallel to these joints bound the quarry on two sides. The rift is on the left, the grain vertical and parallel to the jointing. Quartz and feldspar veins are frequent; some patches occur. Blocks 9 by 2 by 2 feet are the largest that have been shipped from this quarry; blocks 60 by 10 by 7 feet have been started by blasting; there are natural blocks in the quarry 75 by 20 by 4 feet. It is a dark gray, indistinctly-laminated biotite granite, is a safe and free-working stone, and takes a good polish.

Three and a half miles south of Turner, Androscoggin county, there is a quarry producing granite for general building and cemetery work, and used chiefly at Lewiston, Auburn, and vicinity. It was used in the construction of the Lewiston dam, the Episcopal church, Lewiston, and in the Phoenix block, Auburn. The stone lies in sheets of from 1 foot to 6 feet in thickness; the principal joints run northeast, and the grain is parallel to them. The rift is quite good, and is horizontal or in the left. There are occasional patches in the stone, and white stripes are quite frequent. In producing the material for monumental work these defects cause considerable waste. Blocks 9 by 6 feet by 8 inches have been quarried. It is a dark gray biotite granite, is a good and safe working stone, and takes a good polish.

Two and a half miles south of the dip in Brunswick, Cumberland county, granite is quarried to a limited extent for underpinning and wall work, used at Brunswick, Harpswell, Topsham, and Bath. It was used to some extent in Denison's block, in Brunswick, and in the foundation of Memorial hall, Bowdoin college; Parish church, Portland; Bowdoin College chapel, cotton factory at Brunswick, Exchange building at Bangor, and paper-mill at Topsham.

Memorial hall, Bowdoin college, is quite a large stone structure, with two tall towers, in Norman style of architecture. The stone has stood exposure to the weather very well, but from the use of inferior mortar is greatly disfigured by white efflorescences running down from between the stones. The material itself has a uniform color and the appearance of a quartz in color and splintly cleavage. The mica gives it a glittering appearance, even when seen at a distance. Blocks 40 by 2 feet by 8 inches have been moved, and natural blocks of about 70 by 2 feet by 1 foot are found in the quarry. The stone is a light gray, massive biotite granite, and is a good, safe, free-working stone, taking a good polish.

A few miles south of Pownal Centre granite is quarried for monuments, general building purposes, and street work, and to some extent for columns and polished cemetery work. Paving blocks are sometimes shipped to New York city. The following are some of the buildings in the construction of which the material was used: Gorham normal school; a section of the Lewiston dam; in the lower Lewiston bridge, and the trimmings and foundations of factories there; the stone-work of the Lewiston and the Portland water-works; a portion of the Yarmouth bridge, in Maine, and the larger part of the lower story of the new capitol at Albany, New York.

In one of the quarries the sheets vary from 6 inches to 2 feet in thickness; the rift is on the lift, grain east and west. No sap on the sheets except on the joints, which have an east and west direction, and a dike crosses the quarry parallel to them.

In another quarry the sap is quite thick on the surface of the sheets, remarkably so compared to other quarries in the vicinity, but on the lower sheet it is almost nothing. The sheets are usually less than 5 inches in thickness at the top; the rift is horizontal, the grain has a northeast and southwest direction, the sheets dip east, and great head joints run northeast and southwest through the quarry, though but few of them appear. The stone is quite free from defects. Dikes cross parallel to the headings.

Near Biddeford, York county, granite is quarried for general building purposes and cemetery work, and to some extent for polished columns. It has been used in the construction of sea-walls at Gallup island, point Alton, Long island, and Boston harbor; in the Cross Ledge light-house; the foundation of the new railroad elevator, Jersey City; fine building on Broadway, New York city, in which the material is carved and polished; forts Preble, Scammel and other forts in Portland harbor, and in numerous breakwaters along the coast; supports of the columns, in part, of the Brooklyn elevated railroad; outside structure of the monument to Abraham Lincoln, Springfield, Illinois; Boone Island light-house, Maine; Whalesback light-house, in Portsmouth harbor, and Cochecho mills, Dover, New Hampshire, and new docks in North river, New York city.

In one of the quarries great seams and occasionally a dike parallel to them traverse it in a northeasterly direction, dipping steeply east, and being perpendicular, with a thickness of 12 feet or less. There are also large joints crossing at right angles in sheets, so that the blocks are irregular in shape. The material contains the usual patches of the Biddeford granite.

In another of the principal quarries frequent northeast and southwest seams traverse it with a steep dip to the east, and run through the quarry from top to bottom, and other, though much less frequent, seams at right angles to these. The stone consequently lies in parallel sheets, dipping steeply, and occasionally so cut by the cross-seams as to be in rhomboidal blocks. The rift is vertical and oblique to both sets of joints. There are black patches.

Adjoining this quarry is another one having very much the same conditions, but there are long, nearly vertical, northeast and southwest seams cutting through the quarry. The rift is oblique to either set of joints. The grain or next easiest splitting direction is horizontal, and the hardest splitting direction is parallel to the main northeast and southwest joints, which is very unusual. There are some horizontal joints also, so that much of the jointing is irregular. In some new openings in the vicinity there are two sets of long joints similar to those described in the preceding, and the stone lies more in horizontal sheets than in the other quarries; these sheets are from 1 foot to 7 feet in thickness. The rift is vertical and oblique to the two sets of joints. The material is a gray biotite granite, is a compact, safe, and free-working stone, and takes a good polish.

Between Kennebunkport and the Boston and Maine railroad, in York county, granite is quarried to a limited extent, chiefly for underpinning, and used at Kennebunkport, Saco, and Biddeford. The stone lies in sheets about 4 feet in thickness and in regular shape; it contains patches and white feldspar streaks. Blocks 15 by 2 feet by 6 inches have been quarried for underpinning. There are natural blocks 75 by 30 by 4 feet. It is a light gray biotite granite, coarse in texture, and massive.

From 7 to 10 miles north and northwest of Kennebunkport there are quarries producing granite for general building purposes, polished columns, monuments, and cemetery work. Among the structures in which the stone was used are the Creshore works at Portsmouth, and the vault of a bank at Exeter, New Hampshire; Newburyport Savings bank and a Catholic church; and the foundation of the Boston Bridge Company's building, Cambridge, Massachusetts.

In one of the principal quarries the stone lies in rather irregular sheets and is irregularly jointed. The sheets vary in size, one being from 9 to 12 feet in thickness. The most prominent joints run southeast, and the rift is parallel to these, though not well defined in any direction. There are occasional patches. In another one of the quarries the sheets are not well marked, and the stone lies between great headings running N. 50° E., and dipping steeply to the westward. The rift is vertical and at right angles to the course of the headings. There are few patches.

In another quarry the stone lies in sheets varying from 5 to 9 feet in thickness. The principal vertical joints run southwest through the quarry at intervals, and there is a dike crossing it parallel to these joints. There are also some large headings at right angles to these. The rift is vertical and parallel to one set of headings. Patches are few. Blocks 18 by 20 feet by 20 inches have been quarried, and there are natural blocks of 50 by 30 by 12 feet. The stone is a gray biotite granite, massive, and coarse in texture.

Four miles southeast of South Berwick, York county, granite is extensively quarried for general building purposes and cemetery work. The following are some of the structures in which it was used: Stratford Company's house, near Dover, New Hampshire; stone-work of the Cunningham shoe factory, and a large tomb in the cemetery at South Berwick, Maine. This quarry has not been sufficiently developed to show the jointing, which at present seems very irregular. The stone is free from patches and the rift is horizontal.

NEW HAMPSHIRE.

[Compiled mainly from notes of Professor C. H. Hitchcock.]

GRANITES.

At Plymouth, Grafton county, a massive, gray biotite granite is quarried for general building purposes, culverts, and monumental work. The culverts of the Boston, Concord, and Montreal railroad are built of the Grafton granite. Natural blocks 20 by 15 by 10 feet are found in the quarry, and the material of the stone lies in horizontal sheets from 2 to 10 feet in thickness.

At Lebanon, Grafton county, the granite, properly a biotite-epidote gneiss, is quarried for general building and cemetery work. The principal markets are Lebanon and Hanover, Vermont. Natural blocks 10 by 10 by 40 feet are found in the quarry. There are obscure signs of stratification, and dips about 70° northwest. All the quarries here show the same features of dip. The workable granite is in horizontal sheets, and the workmen follow the material horizontally into the hill. The joints dip 70° easterly; one or two have a southeast direction. The rift is horizontal. (See *Geological Report of New Hampshire*, Vol. II, p. 355: "Inverted Dip.")

At Hanover, near Enfield village, Grafton county, a gray, massive biotite granite is quarried for general building purposes. The principal market is Hanover, New Hampshire. The stone lies in sheets varying from 6 inches to 9 feet in thickness. It is coarse in texture and not susceptible of a good polish. Natural blocks 200 by 12 by 9 feet are found, and blocks 23 by 9 by 8 feet have been quarried. Discolored joints are found at all depths to which the stone has yet been quarried.

At Rumney, Grafton county, a gray, massive biotite granite is quarried for monumental and building purposes. The stone was used in the construction of the Franklin monument at Plymouth. It lies in horizontal sheets, and the largest natural blocks are 20 by 5 by 5 feet. It is pronounced by Professor Hitchcock to be of the same horizon (Montalban) as the Concord granite.

At Sunapee, Sullivan county, a massive, biotite-muscovite granite is quarried for monumental and building purposes, and is used principally at Newport and Claremont. There are two principal varieties as to color, a light gray and a dark gray. The sheets have a dip of 25° west. Of the two kinds of granite which have been protruded through the porphyritic gneiss at this place black granite is the oldest, which is known from the fact that pieces of it are found in the light-colored granite. This light granite is really the equivalent of what, in Professor Hitchcock's report on New Hampshire, is called the "Upper Bethlehem", but he pronounces it an eruptive granite. Dr. George W. Hawes, in his first catalogue of lithology for New Hampshire, calls this black granite a mica schist. The black granite has the usual appearance of an erupted mass; the ledge of white granite does not reach 100 feet in width, therefore the quarry is limited though well situated. The seam of epidote lies between the two granites. Both varieties are compact, good, and safe stones to work, and take a high polish.

At West Concord, Merrimack county, a massive, gray biotite-muscovite granite is quarried for general building purposes and cemeteries. Among the prominent buildings in which the stone was used are the Horticultural hall, Security bank, the city hall, and Masonic temple, Boston; the Philadelphia city and county building (part), and the Massachusetts state prison, and the *Herald* building, Boston.

At Concord a massive biotite-muscovite granite is quarried for monumental and building purposes. Among the prominent buildings in the construction of which this stone has been used are the Life Insurance Company's building, Boston; monument to the discoverer of anæsthetics, at Public garden, Boston, and the Cadet monument Mount Auburn cemetery, Cambridge, Massachusetts; soldiers' monument, Concord, Massachusetts; Charter Oak Insurance building, Hartford, Connecticut; Jordan & Marsh's building; soldiers' monument at Manchester, New Hampshire; Equitable Life Insurance and Germania Savings Bank buildings, and the city hall and Horticultural hall, Boston, Massachusetts. It is a good, safe, and free stone to work, and takes a high polish. For commercial purposes this granite is divided into four classes: 1st, the best for monumental work; 2d, the next best for general building purposes, where one good face is sufficient; 3d, second quality of stock, including much of the underpinning for ordinary dwelling-houses, steps, capping for walls, and hitching posts; 4th, foundation stones, piers, and abutments, and other uses in which uniformity of color is not desired.

Some of the principal quarries are situated on what is known as Rattle Snake hill, which elevation consists almost wholly of a granite formation. The stone on the south side is very light colored; that on the north side is darker. The elevation is 600 feet above the Merrimack river, and the distance from the river to the crest of the hill is 2 miles. The surface of the rock is polished down by glacial action as smooth as an earthen plate. There are some patches of a darker color than the prevailing material, some of which are 18 inches in diameter. Masses of quartz from 1 inch to 6 inches in diameter occasionally occur in the stone. The rift inclines to the west about 1 inch to the foot, and the grain is vertical, having a north and south direction. There are also some joints having a southeast and northwest direction crossing the regular east and west joints. In one of the principal quarries on the east side of the hill the stone fractures best with an east and west line.

Oak hill is a similar elevation to Rattle Snake hill, and is also a granite formation, but the material is usually coarser and more broken. Dikes running through the hill cause variations in the structure of the mass.

A massive, gray biotite-muscovite granite is quarried at Allenstown, Merrimack county, for general building purposes and cemetery work. The natural advantages of this quarry are of the very best, and few of the New

Hampshire quarries are better situated for drainage, size of sheets, availability, and convenience to railroad and markets. It is on the Concord railroad, midway between Concord and Manchester. The material is of medium fine texture, and is jointed horizontally and vertically. There are natural blocks 80 by 20 by 10 feet.

At Durham, Strafford county, a massive, gray biotite granite is quarried for foundations and for flagging. It was used in the foundation of Sawyer's mill, and most of the buildings in Dover, and is transported by boat and wagon. It is coarse in texture, and is a good and safe stone to work, taking a good polish. It lies in sheets of from 6 inches to 2 feet in thickness, inclining to the west. There are natural blocks 20 by 15 by 4 feet in thickness. It lies at the horizon called by Professor Hitchcock "Exeter syenite".

At Raymond, Rockingham county, a pinkish-gray, indistinctly-laminated biotite granite is quarried for general building purposes and cemetery work. The principal markets are the large towns in the neighborhood. The stone was used in the foundations of the custom-house at Portsmouth. The texture is medium fine, and has a jointing similar to the granite quarried at Manchester. Blocks 24 feet square have been quarried. This granite works well and takes a good polish. Professor Hitchcock reports this stone as weak and not likely to be much used save where good stone is scarce, as in the lower part of New Hampshire.

At Peterborough, Hillsborough county, a light gray, laminated muscovite-biotite granite is quarried for general building purposes and curbing. The principal markets are Worcester, Lowell, and Lawrence, Massachusetts. This stone is sometimes called a gneiss from its distinctly-laminated structure; it would perhaps be more proper to term it a gneiss than a granite. It splits readily in the direction of the lamination and takes a good polish. The texture is coarse, and the sheets incline 70° to 75° west. Blocks 28 by 6 by 10 feet have been quarried, and natural blocks 36 by 6 by 12 feet are found in the quarry.

At Milford, Hillsborough county, a gray, indistinctly-laminated biotite granite is quarried for general building purposes and cemetery work. The prominent buildings in the construction of which this stone has been used are the Merchants' exchange, Nashua, and the engine-house at Lowell; the town hall at Wakefield and court-house in Worcester, Massachusetts; and the Wilcox block, at Windsor, Connecticut.

There is quite a number of different quarries in this granite near Milford, and the material is generally a good and safe stone to work, taking a good polish. Blocks of any desired size are found in these quarries, and in many places there are irregular, large, vertical dirt joints, and in some of them coarse sand from 2 inches to 2 feet in thickness separates the sheets.

At Mason, Hillsborough county, a gray, indistinctly-laminated biotite granite is quarried for cemetery and street work and general building purposes. The principal markets are Lowell, Worcester, and Walton, Massachusetts. There is quite a number of very coarse granite veins, varying in thickness from 2 inches to 2 feet, which are called "salt veins" by the quarrymen. The larger blocks of granite are quarried with facility, by reason of the existence of these small veins. The stone is of medium-fine texture, is good and safe to work, and takes a very high polish. In one of the principal quarries the typical two sets of joints cross each other, and are very regular, a fact which is not, however, unusual in the granite of this region. Seams of clay sometimes are infiltrated into the joints. With regard to the joints Professor Hitchcock states that all the New Hampshire quarries have usually the following: 1st, a set of horizontal seams or joints, enabling the workmen to raise the stone parallel to the surface; 2d, vertical joints, usually well pronounced; 3d, scattering joints, often causing the rectangular blocks produced by the first two sets to become wedge-shaped. Sometimes only one of these wedges is worked. Invariably these seams that are highly inclined, if pronounced, carry some dirt derived from muddy water. Many quarries have no scattering joints at all. The line governing their occurrence has not yet been discovered.

Near Nashua, Hillsborough county, a light gray, indistinctly-laminated muscovite granite is quarried for foundation and dimension work. This stone is well adapted to foundations, buildings, and street and cemetery work, where simple rock-faced work is required, but is not adapted to ornamental or fine hammered work. For better classes of building purposes in this vicinity the Nashua granite is used, and the Concord granite for ornamental work. Slabs 20 feet long, for cemetery borders and underpinning, have been obtained from this quarry.

At Wilson hill, $1\frac{1}{2}$ miles from Manchester station, Concord railroad, Hillsborough county, a pinkish-gray, indistinctly-laminated biotite granite is quarried for foundations and underpinnings and trimmings for buildings. The principal market is Manchester. It is assigned geologically to the lake gneiss. The texture is coarse, and has the usual horizontal and vertical jointing of New Hampshire granites. It is of value chiefly because within the limits of the considerable city of Manchester.

At Fitzwilliam, Cheshire county, a massive gray granite is quarried for general building purposes, ornamental work, and paving. The principal markets are New England and the west. Among the structures in which this stone has been used are Saint Paul's church, Worcester, and the trimmings of Murdock block, and the national bank, Winchendon, Massachusetts; soldiers' monument at Granville, New York; Keene (New Hampshire) court-house; court-house at Albany, New York; trimmings of Morse Institute, Natick; court-house at Fitchburg, and Kruff's block, Pearl street, Boston, Massachusetts. The Fitzwilliam granite is of a fine or medium-fine texture, and varies in its ingredients so that the microscope shows specimens from some quarries to be muscovite-biotite granite; from others, biotite granite; and some of the material is laminated so that it may be termed a gneiss. In one of the principal

quarries there is a light gray muscovite granite and a dark gray biotite granite. The geological horizon is that of the Montalban Archæan rocks. The position of one of these quarries is mentioned as particularly favorable; it is located on the broad north slope of a hill, drains itself, and a very large surface has been exposed to view. If at all defective, it is in the existence of many thin sheets. The Fitzwilliam granites are generally compact, free, and safe-working stones, taking good polish.

One and one-quarter miles east of the depot of Marlborough, Cheshire county, a gray, massive biotite granite is quarried for building and paving purposes. Among the prominent buildings in the construction of which this stone was used are a church and the Union depot, Worcester, Massachusetts; stone mill at Harrisonville, railroad bridge at Keene, and library building in Marlborough, New Hampshire. The stone lies in sheets which are inclined from 20° to 50°, and vary in thickness from 3 inches to 3 feet. There are natural blocks as large as 30 by 14 by 2½ feet. The stone is good and safe to work, and takes the highest polish. Geological horizon, Montalban.

At Troy, Cheshire county, granite is occasionally quarried for local purposes. It was used in the construction of the bank and court-house in Fitchburg. Some of the quarries there produce excellent material for curbing, being hard and brittle, but free from iron.

At Roxbury, Cheshire county, granite is occasionally quarried for local purposes, and it was used to some extent in the construction of the state-house, in Albany, New York, which was in fact the chief purpose for which the quarries were operated.

VERMONT.

[Compiled mainly from notes of Professor C. H. Hitchcock.]

MARBLES AND LIMESTONES.

The noted marble districts of Vermont are in the vicinity of Rutland and Sutherland Falls, Rutland county; Dorset, Bennington county, and on the islands and near the shores of lake Champlain, in Grand Isle and Franklin counties, known generally as Lake Champlain marble. The marble of Rutland and Bennington counties is used very extensively throughout the United States for general building and monumental purposes, and is among the most widely known marbles in the country. According to the classification adopted in this report, this material varies sufficiently in its composition so that some of it may be properly called a limestone, some of it a magnesian limestone, and some calcareous dolomite. Like nearly all the other material known in the markets as marble which is quarried in this country, it belongs to the Lower Silurian formation. The strata of the rock are usually inclined at various angles, and the courses are of such thickness and the jointing is of such a nature that blocks of any desired size may be obtained. In color it varies from white to a dark bluish, and some of the white is of such quality that it is used for statuary purposes.

The Lake Champlain marble from Swanton, Isle La Motte, and other places in this district varies in its composition so that it is sometimes a magnesian limestone and sometimes a dolomite. It is used chiefly for interior work, mantels, tables, inlaid work, and tiling, and may be seen in many of the most important structures in the country. It is of various mottled and variegated colors. Some of the quarries produce black marble. The variegated appearance of some of this marble is heightened by its highly fossiliferous nature.

GRANITES.

Nearly all of the granites quarried in Vermont are of the Calcareous mica-schist, a formation which Hitchcock states may be as late as Devonian, certainly not earlier than Upper Silurian. They are usually biotite granites of various shades of gray, and have not as extensive a use throughout the country generally as the New England granites situated on the coast—a fact probably due to the less expensive means of transportation of the coast granites. The Saint Johnsbury granite, which, according to Winchell, belongs to the lake group of New Hampshire, is quarried extensively, and is marketed chiefly in the neighboring cities of New York.

SLATES.

The important slate formation of Rutland county, Vermont, is, according to Hitchcock, of Cambrian age. The principal quarries are near Northfield, Castleton, Fairhaven, Poultney, and Powlet, and produce material for roofing, mantels, billiard tables, tiles, school slates, trays, sinks, furniture, and for ornamental and various other purposes. The different colored slates obtained are chiefly a bluish-black, purple, and green. They are used throughout the United States for the purposes before mentioned.

CONNECTICUT.

[Compiled mainly from notes by Harrison W. Lindsley.]

BROWN AND RED SANDSTONE, TRIASSIC FORMATION.

The surface rocks of Connecticut are Archæan rocks, covering most of the area of the state; a small Lower Silurian area, chiefly in the northwest corner of the state, producing limestones which thus far have been quarried only to a limited extent for purposes of construction; and the Triassic rocks of the Connecticut valley, extending,

according to Professor J. D. Dana, from New Haven, on Long Island sound, to northern Massachusetts, having a length of 110 miles and an average width of 20 miles. This formation furnishes the celebrated brown sandstone quarried at Portland and at other places in the Connecticut valley. The principal quarries are at Portland and at Middletown, on the east bank of the Connecticut river, near the junction of the Air-Line and the Connecticut Valley railroads, in Middlesex county. These quarries are operated on a very extensive scale, and the most improved methods of quarrying are in use, the work being largely done with steam channeling-machines, as the stone is of such a nature that it is readily cut in this way.

The "Connecticut brownstone", as it is known in the market, is extensively used for all kinds of building and monumental work in the principal cities of the Atlantic border, in Canada, and in Chicago. Most of the fronts on Fifth and Madison avenues, New York city, are built of this stone. Transportation is by boat and by rail. The wharves are situated within 100 yards of the quarries, and railroad tracks are extended into the quarries. The material is very uniform in character and appearance. A considerable quantity of stone from each of the quarries was used in the construction of the Vanderbilt brownstone house on Fifth avenue, New York, and was used indiscriminately in the front of the building. Blocks about 30 by 7 by 7 feet have been moved in the quarry, and there are natural blocks as large as 100 by 50 by 20 feet, so that blocks of any desired size may be obtained. This stone splits in uniform layers from one-sixteenth of an inch in thickness to 15 or 20 feet thick. The texture is medium as to fineness of grain compared with other sandstones, and is very uniform. According to Dana this sandstone is largely a granitic sand-rock made of pulverized granite or gneiss. The following analysis of a specimen was obtained by Mr. F. W. Taylor, chemist of the National Museum:

	Per cent.
Silica.....	69.94
Iron sesquioxide.....	2.48
Alumina.....	13.55
Lime.....	3.09
Magnesia.....	trace
Soda.....	5.43
Potash.....	3.30
Ignis iron.....	1.01
Manganic oxide.....	0.70
	<hr/>
	99.50

The Connecticut brownstone should invariably be laid in walls as it lay in the quarry bed, as the signs of stratification are usually distinct, and the material has a tendency to split when set on edge.

There are also extensive brownstone quarries at East Haven, near New Haven, on the Air-Line railroad. The stone at these quarries differs in some respects from that quarried at Portland; it is here a reddish, rather coarse stone, containing much quartz in grains, and is employed chiefly for foundations, underpinnings, and railroad work at New Haven, and by the railroad companies of Connecticut and Massachusetts. It was used in the construction of Saint Paul's church, New Haven, and for the abutments and piers of numerous railroad bridges. The stone is in quite uniform layers 2 or 3 feet in thickness, and blocks 20 by 4 by 3 feet have been obtained. The joints are not frequent and are quite irregular.

Small quarries of the Triassic sandstone are operated at several other points chiefly for local use. Among these points may be mentioned Buckland station, Hartford county, on the Hartford, Providence, and Fishkill railroad, where stone of a very beautiful reddish color, but slightly coarser grained than the Portland stone, is obtained. The material here seems to be in every way suitable to all general building purposes, and can be obtained in blocks of any size ordinarily required. The quarry has also good facilities for transportation by rail.

At Hayden's station, within a few yards of the New York, New Haven, and Hartford railroad, is a quarry of brown sandstone formerly operated to supply stone for the dam at Windsor ferry. It has been operated for local uses for a hundred years. The stone is similar to the Portland stone, but somewhat redder in color, and as there are good facilities for transportation, both by railroad and river, it may be of importance in the future.

At Suffield, Hartford county, there are a number of small brownstone quarries, none of which have been operated except for local or private purposes. Other quarries are operated for local purposes at Newington, Hartford county, Farmington, and Forestville. It will be noticed, however, that the extensive quarrying in Connecticut on this formation is done only at Portland and East Haven.

The principal quarries on the trap dikes of the Triassic age in Connecticut are at East rock and West rock, north of New Haven. The material here is diabase, nearly black in color, fine and uniform in texture, and it is used for cellar stone and street paving in New Haven. This rock is much cut by irregular joints, so that blocks of a size suitable only for cellar work and paving stone can be obtained; however, it serves well for these purposes.

GRANITE AND SYENITE.

Extensive quarries of granite and gneiss are located at various points in the state, especially near Thomaston and Roxbury, in Richfield county; on Long Island sound, in Fairfield county; near Ansonia, Branford, and Stony creek, New Haven county; Middletown and Haddam, Middlesex county; and near Lyme, Niantic, Groton, and Mason's

island, New London county. The Connecticut granites and gneisses are usually fine grained and light gray in color, and the appearance is usually so characteristic as to distinguish them from other granites of the Atlantic Coast states.

At Sterling, Windham county, a biotite gneiss, rather coarse in texture, and varying in color from gray to light gray with a pinkish tint, is extensively quarried for general building purposes, monuments, and street work, and is shipped chiefly to Willimantic, Jewett City, Danielsonville, and Baltic, Connecticut, and to Providence and Warwick, Rhode Island. Among the structures in which it has been used are the Furnace block in Willimantic, the Baltic mill, and mills at Warwick, Rhode Island.

Near Thomaston, on the Naugatuck railroad, a light gray biotite-muscovite granite is quarried extensively for general building purposes, and shipped to Waterbury and the towns in the western part of Connecticut generally. Among the buildings in which it was used are the United States building (front), New Haven, and the Episcopal church, Waterbury. The material in the quarry lies in quite irregular sheets, usually inclined about 20°, and has a slightly gneissoid or laminated structure.

At Roxbury, the granite quarried for curbs, foundations, and paving, and employed chiefly in Danbury, Connecticut, and New York city, is similar in structure and composition to the Thomaston granite.

The quarries on the shore of Long Island sound produce a hornblende-biotite gneiss, used extensively for foundations, underpinnings, footings, and piers in New York city and Brooklyn. Transportation is by schooner on Long Island sound. The color of this material is a very dark gray, approaching black.

Near Ansonia a bluish-gray muscovite-biotite gneiss is quarried for general building purposes and used in the vicinity, at New Haven and Bridgeport. Among the structures in which it was used are the copper-mill and clock shops in Ansonia, and Howard Avenue church, New Haven. This gneiss splits very evenly in slabs of almost any thickness. Slabs of 4 inches in thickness can be obtained about 2 feet in width and from 4 to 6 feet long. The rock on the natural surface looks fibrous like a piece of straight-grained wood, and splits vertically in the direction of this grain as well as in the plane of the quarry bed. It can be successfully polished only at right angles to the plane of lamination. A large seam of quartz about 6 feet square in the section crosses on top of this quarry in almost a straight line, having a direction northeast and southwest. This rock is exposed at many points in the vicinity, and probably could be profitably worked at nearly all of the outcrops.

Near Branford the material, though locally called granite, is a biotite gneiss, and has thus far been used for breakwaters and coast engineering works at fort Jefferson and New Haven. A portion of the breakwater in New Haven harbor was constructed of this material. It is shipped in barges. This stone is not very uniform in texture and color; even in the same quarry it varies in color from dark gray to a pink.

A biotite granite is quite extensively quarried at Leetes Island station, 6 miles east of Branford, on the Shore Line railroad, in New Haven county. It is used for general and ornamental purposes, chiefly in New York city. Among the structures in which it has been used are the bridges at Springfield and Harlem. It is transported by boats.

The stone quarried at Arnold's station and Maromas station, on the Connecticut Valley railroad, in Middlesex county, is a very dark gray or black hornblende-biotite gneiss, varying from fine to coarse in texture, and used chiefly for curbs, flagging, and steps and street work at Philadelphia, Pennsylvania, Camden, New Jersey, and Springfield, Massachusetts. It is transported by schooners and boats. This rock is considerably marked with fine white veins from one-eighth of an inch to 2 inches wide running irregularly through it. There are occasional quite large veins of quartz, much stained with iron, running through the ledge, but the iron stains are only on the surface. This stone was called blue-stone in the market before the North River blue-stone was extensively used. There is a streak running through portions of the ledge of very much finer and darker colored stone, which splits with a smooth, almost black surface, due to the black-mica scales. Nearly all the mica in this rock is black, and to this fact is due the very dark color of the material.

Material of a similar nature has been quarried at Deep river, at Saybrook, Hadlyme, and Haddam, on the east bank of the Connecticut. In the principal quarries the cleavage is nearly vertical and at right angles to the beds, thus making it easy to obtain blocks of required shape.

At Maromas station the quarry rock is without any jointing or division into sheets, being a solid mass, excepting near the surface. It splits, however, very easily in horizontal planes in any thickness, is very uniform in appearance throughout, and very easily quarried. The quarry is at such a level that it can be drained by the siphon. It is close to the Connecticut river and the Connecticut Valley railway, so that the facilities for transportation are good.

The quarries near Lyme, Niantic, Groton, and Mason's island produce chiefly a gray biotite granite. There is, however, one quarry near Lyme producing a red granite, locally called "red porphyry". The texture is coarse and porphyritic; it is used for general building and ornamental purposes, chiefly at Newport, Rhode Island. Some of the material may be seen in the Chaney Memorial church, Newport, Rhode Island.

The other principal quarry near Lyme produces a plain gray granite, rather coarse in texture, and shows on all dressed surfaces fine parallel lines of alternate dark and gray. These lines prevent its use for the most highly ornamental purposes, as they usually run obliquely across some or all of the finished surfaces. Portions of the material in this quarry are slightly pinkish in color.

The Niantic quarries produce a light gray granite of rather fine and uniform grain, used for general building purposes, monuments, and paving, chiefly in New York city, though it is used in various places in Connecticut and Rhode Island, and has been shipped as far south as Savannah. It is transported by boats. Among the structures in which it has been used are the Norwich court-house, the New York reservoir, and fort Adams, Newport, Rhode Island. The surface rock of this and other granite quarries in the southeastern part of the state is thought to be looser in texture than the rock below and much more easily broken. It is often coarser and less uniform in texture. The usual thickness of this surface rock is from 5 to 15 feet. It is utilized for riprap and similar rough purposes, and may be considered as the lowest grade of the production of these quarries. At the Niantic quarries there are two grades, the finest grain being a perfectly uniform gray in color on a polished surface, and the second having a polished surface covered with spots from one-half to three-quarters of an inch in diameter, quite uniformly spaced from 1 inch to 3 inches apart, and looking much as if a wet finger had been repeatedly applied to the smooth surface. The discoloration in natural joints does not penetrate the stone at all, but discolors the whole surface of the joints as far as it extends.

These quarries are the largest located on Long Island shore between New Haven and the Rhode Island line. They have supplied material for a large number of the ports along the Atlantic coast and for government works at many other places. A small portion of the material at certain sections in the quarries is slightly pinkish in color.

The granite quarried at Groton is a light gray material of a rather fine and uniform grain. It is used for cemetery work, monuments, curbs, trimmings, and breakwaters, chiefly at Providence, New Haven, Hartford, Buffalo, Erie, Milwaukee, Cincinnati, and Chicago. The transportation is partly by boat, but chiefly by rail. Nearly all of the material of the best quality produced by these quarries is used for ornamental work, as it is uniform in color and texture and takes a fine polish. Much of the stone shipped from these quarries is dressed and finished.

At Mason's island, south of the Mystic river, Long Island sound, a gray granite is extensively quarried for riprap and breakwaters. The ledge is very much broken by joints, and blocks of large size are not readily obtained, though the quality and structure of the material and the location of the quarries make it well adapted and convenient for the purposes for which it is used. The material thus far quarried has been chiefly the surface rock. At several places, however, large sheets of what seemed to be much more uniform and better granite have been reached. The rough rock overlying these sheets is from 15 to 30 feet thick.

At Mystic River there is a granite quarry producing a fine quality of gray granite, which may be obtained in blocks of any desired size. As yet, however, it has not been much operated. This quarry is situated on the side of a steep cliff or ledge, very accessible and conveniently located for quarrying, near the Mystic river.

At North Bridgeport, Fairfield county, and Killingly, Windham county, gray and rather coarse-textured hornblende-biotite gneiss is quarried for local use. A material of similar character is quarried at Willimantic for curbing and flagging, chiefly for local use. Fine-grained gray-biotite gneiss is quarried at Bolton, Tolland county, for flagging, and used chiefly in Hartford; it is, however, shipped to some extent to other New England cities.

Dark gray biotite gneiss is quarried for street work at Glastonbury, Hartford county, and used chiefly in Hartford.

At West Norfolk, Litchfield county, a very beautiful light gray, fine-grained gneiss is quarried. It is uniform in texture and color, and has a bright, fresh appearance. It is nearly all distinctly laminated, and is a biotite-muscovite gneiss, though specimens forwarded to the National Museum are properly called "granites".

SERPENTINE AND VERD-ANTIQUE MARBLE.

In the Archæan rocks near New Haven are deposits of serpentine and verd-antique marble, which have not thus far been quarried to any great extent, although if worked they would furnish excellent material for interior decoration and other ornamental purposes.

The serpentine is gray, mottled, yellowish, and greenish in color when rough; when polished it is dove-colored, with lines of yellow and green.

The verd-antique marble is of a grayish color when rough; when polished it is dove-colored, yellow, greenish-yellow, and black and white. The difficulty of dressing and polishing this material seems to have prevented its extensive use thus far.

NEW YORK.

[Compiled mainly from notes by Professors Cook and Smock.]

GRANITE.

Granitic rocks are quarried for local use in a number of localities in Westchester county, and the material is generally fit for rough work only. The gneiss quarried near Hastings by Messrs. Munson & Co., however, is used principally in New York city for foundations and general construction purposes. This is a rather coarse grained material, and is striped by alternate layers of light and dark, varying in thickness. Nearly all varieties, as to color, texture, and composition, occur in this region, though no very valuable exposures have been developed in localities convenient to water transportation.

In Putnam county the granitic rocks are well developed, and have been worked in various localities in cliffs along the Hudson river.

On Grindstone island, one of the Thousand islands, Jefferson county, a beautiful red granite is obtained, which is rather hard to dress, but is susceptible of being very highly polished.

The product of the quarry is at present manufactured into paving blocks and stones for monumental work; the former are used in Chicago, Illinois, and the latter are shipped to Montreal. The quarry is favorably located for transportation by the great lakes and the Saint Lawrence River system of navigation; it is on the west side of Grindstone island, about 5 miles west of Clayton, Jefferson county, and at the dock adjoining the quarry vessels of 400 tons burden can land.

SANDSTONE.

At Malone, Franklin county, the Potsdam sandstone is crossed by the Salmon river, and here some stone is quarried for local demands, but no quarries were reported as worked during the census year.

Three miles south of Potsdam, Saint Lawrence county, the Raquette river cuts across the Potsdam formation, and quarries are worked along the banks of this stream. The outcrop of the sandstone where it is cut across by the river is about 2 miles in width from north to south. The strata dip in a southerly direction at an angle of 45°. The formation shows signs of disturbance, and the layers near the surface are thin and are used for flagging. As the excavation proceeds downward the layers gradually increase in thickness until, in the bottom of the quarry, at a depth of about 40 feet, the layers are from 2 to 3 feet thick. These layers split readily, when first quarried, into any desired thickness. The stone works well when first taken out, but becomes quite hard upon exposure. Much of this stone has a pleasant reddish-brown color, which is very durable, but some of it shows a rusty discoloration upon long exposure. It is quite refractory, and is used for lining cupolas in the furnaces at Potsdam. A large amount of it has been shipped to New York for use in the construction of the new buildings of Columbia college; three churches, the Normal School building, and the town hall at Potsdam, are also built of this stone. The most westerly point where the Potsdam sandstone is worked is at Hammond, in the extreme western part of Saint Lawrence county. The strata here are very nearly horizontal, but the jointing is irregular. The stone is of good quality, and varies in color from gray to red. Thin layers also occur at the top at this point, and heavy layers are found lower. The quarry is conveniently located for transportation, and the stone is used for curbs, flagging, and paving, principally in towns of central New York.

In Washington county the Potsdam sandstone is from 50 to 60 feet thick, generally covered by alluvium, and nowhere extensively quarried. At Fort Ann it is almost pure quartz, and is quarried for use in the steel-works at Troy, and also for the construction of hearths. There are some small calciferous-sandstone quarries in the vicinity of Fort Ann, which furnish excellent paving stone and stone for underpinnings for local use.

In Schenectady county, at a point called Aqueduct, a valuable development of a sandstone stratum in the Hudson River group occurs. It is a very fine-grained, stratified sandstone, in layers separated by thin seams of slate, and the sandstone grades almost imperceptibly into slate. The strata dip slightly to the southwest, and a system of parallel joints, called side seams, runs nearly northeast and southwest, and is cut across at right angles by cross joints. There are main side seams from 30 to 55 feet apart, very regular and filled with mud, and between these there are irregular parallel joints at distances of from 2 to 12 feet apart. In the southward extension of the formation the strata of slate run out and several sandstone layers unite and thus furnish large-sized blocks. The quarry is located on the bank of the Erie canal, by which the stone is transported to market, and the quarrying is done during the season of canal navigation. The stone works well and is used quite largely for buildings in surrounding cities.

BLUE-STONE DISTRICT.

The "flagging" or "blue-stone" of the Hudson River district belongs to several geological formations from the Hamilton upward. The district is confined to comparatively narrow limits west of the Hudson river, and mainly to Albany, Greene, and Ulster counties. It begins with the quarries in Schoharie county, passes to the southeast and enters Albany county near Berne, and from there passes around to the south and southwest, across Greene, Ulster, and Sullivan counties and across the west end of Orange county, to the Delaware river and into Pike county, Pennsylvania. There are no quarries known in any of the formations below the Hamilton down to the Hudson River slate, and the typical blue-stone flagging may all be said to come from the Hamilton formation, which, according to Professor Hall, is succeeded by the Oneonta sandstone, the equivalent of the Portage in the eastern part of the state. The Chemung shales and sandstones have not been identified, and the gray and the red beds of the Catskill mountains probably belong to the Catskill group. It may yet be found that the main blue-stone belt, which extends southwest through Hurley, Ulster county, belongs in part to the Hamilton, while the upper or western beds are of the Oneonta formation. The flat plateau or terrace to the east and southeast may be occupied by the softer Chemung rocks. If this be the case, the quarries of West Saugerties, High Woods, Shandaken, Phoenicia, Boiceville, and Brodhead are all in the Catskill group. The stone from these localities is generally coarser grained than that from the more eastern range, and the gray or the reddish tints predominate over the dark blue-black shades.

The quarry at Eminence, Schoharie county, is probably in the Chemung group. The quarries which are probably in the Hamilton group are the Middleburgh quarry, Schoharie county, the Albany County quarries, those of Greene county and of Quarryville, Saugerties, Kingston, and West Hurley, Ulster county, and those in the southwestern extension of the blue-stone district near Ellenville, Ulster county, and at Pond Eddy and West Brookville, Sullivan county. There is a great number of quarries in this district, and many of them are very small, as little capital is needed to develop a quarry, on account of the small amount of cap-rock to be removed and the little machinery necessary to operate the quarries, as they are worked almost exclusively for flag-stones of small size and small "edge stuff".

In Schoharie county the character of the flag-stone is much the same as in the quarries along the Hudson river. There are in the blue-stone formation always two systems of joints crossing each other nearly at right angles. Those of the principal system, which usually runs nearly north and south, are called "main side joints", and the others "cross joints". In the Eminence quarry the main joints run nearly north and south, and the strata dip slightly to the south or southwest. Several ledges are quarried here at different elevations, and the stone varies in texture, the highest strata being coarse-grained and varying in color from gray to red, and the lower layers are blue-black and fine-grained. The product of these quarries is principally flag-stone, which is used to supply the local demands of surrounding towns. The quarries of the Middleburgh Blue Stone Company are about a dozen small openings near Hunter's Land, and from 5 to 10 miles east and southeast of Middleburgh. The quarries are nearly all in side hills and the strata are very nearly horizontal. Near the surface a hard, thinly-bedded stone is found, which is suitable for common flagging, cross-walks, and rough work. The quality of the stone is found to improve as the quarries are worked to greater depth, heavier beds of finer-grained and more valuable stone being found. This is a newly-developed blue-stone district, and some of the best stone is suitable for trimmings. The material goes principally to Albany, Troy, and other cities to the northeast.

The stone from the Albany County quarries is coarser, harder, and more gray in color than that from the same formation in Greene and Ulster counties. The Reidsville quarries have an average thickness of workable strata of only 4 feet, covered with from 2 to 14 feet of earth and slaty beds. The quarries in the vicinity of Dormansville were formerly worked quite extensively, but for several years past they have been worked but little. The beds in these quarries are thin, and the stone goes principally to Albany for flag-stone. At Stephenville, 6 miles west of Coeymans, a more easterly range of flagging stone occurs, which, however, has not yet been developed.

The blue-stone belt, extending south from Albany into Greene county, crosses New Baltimore and Coxsackie townships, in each of which quarries have been opened, though very little stone has been taken out. At New Baltimore stone is quarried for dock filling at Albany.

The Leeds quarries consist of six or seven different openings, which are worked at intervals by farmers. The product of the quarries, most of which is for small flags, is carted to Catskill, a distance of about 2 miles. The Kiskatom quarries have been worked, but not continuously, for many years. The blue-stone belt is here quite narrow, and in the ledge worked approaches near to the limestone formations that lie between it and the Hudson. The structure of the beds is similar to that of the same formation farther south. The shipping points for these quarries are Catskill, Malden, and Smith's Landing, from 7 to 8 miles distant. The cost of carting the stone amounts to about 25 per cent. of the value at these points. The stones produced are mostly of small size, and are worked into curbs, caps, sills, steps, etc., called "edge stuff". At Palenville a large number of quarries was formerly worked, extending over a large space, but the decline in prices has put a stop to many of them. The quarries are all at the base of the mountains and several hundred feet above the surrounding lowlands, and a good quality of stone and large-sized blocks may be obtained. The strata dip westward into the mountains, and the thickness of cap-rock increases rapidly in that direction. The distance of these quarries from Malden, the shipping point, is 9 miles.

Ulster county has by far the largest number of quarries in the blue-stone district. Quarryville, in the northwestern part of Saugerties township, is a noted quarry district, which has been worked for 40 or more years, and a large amount of stone has been taken from it. The stone is sold at Malden, and is drawn there over a tramway constructed of blocks of stone. There is much less stone quarried here at present than was formerly produced, as the depth of stripping has increased to such an extent that the quarries can be worked with but little profit. The stone is of good quality and is used for turned and general dressed work at the Malden yards. The quarries lie in lines along three parallel ledges which have a general direction from northeast to southwest. There the blue-stone belt makes its nearest approach to the Hudson, the limestone belt, $3\frac{1}{2}$ miles in width, separating the most easterly ledge from the river. The beds of sandstone overlie each other from west to east, and strata of slate and hard sandstone occur between them. The vertical side seams are very regular and run north 40° east, and the joints at right angles to these are irregular and not continuous. The quarries in the easternmost ledge extend about a mile in length, 175 feet in width, and have been worked to an average depth of about 12 feet. A large area has been left on account of the heavy stripping required.

The line of quarries in the middle ledge extends over an area about $1\frac{1}{2}$ miles in length, from 150 to 500 feet in width, and has been quarried to a depth of from 12 to 20 feet. Quite heavy beds occur in some of these quarries, and the joints often allow blocks of very large size to be obtained. In the western ledge the quarries are in a line about

1,000 feet long by 150 wide, and are worked to an average depth of about 12 feet. These quarries are about 5 miles from Malden, being the most distant of all quarries here noted. The total thickness of workable layers in the Quarryville region is from 4 to 20 feet, and the stripping is from 6 to 17 feet in depth. Much of the heavy or thickly-bedded stone is taken to Malden to be worked into edge stuff. In working these quarries little capital is used beyond the value of the necessary tools. Leaseholds are common, and the royalty paid is at the rate of one-half cent per square foot of stone quarried. The larger sizes of blocks have bed dimensions of about 15 by 8 feet, although some 25 by 15 feet have been taken out. The quarries near Saugerties extend in a line from northeast to southwest, about 2 miles in length and half a mile in breadth, and are known as the Fish Creek quarries. A large area has been quarried over and a large amount of stone has been taken out. The quarries have been in operation from thirty-five to forty years, but the product is now small and is carted to Saugerties, which is from 4 to 5 miles distant, and the cost of carting amounts to one-third of the value of the stone at that place. The quarries now worked are in the midst of the old works, many of them previously abandoned. They are now not very productive, and a considerable amount of stripping is necessary. The quarry bed is from $3\frac{1}{2}$ to 8 feet thick, and the stripping or cap-rock from $3\frac{1}{2}$ to 7 feet thick. The stone is fine-grained and is used mainly for edge stone. The Kingston quarries are all in the same belt, and may be separated into several groups, as the Dutch Settlement group, the Hallihan's Hill group, the Sawkill group, the Jockey Hill group, and the Dutch Hill group.

In the Dutch Settlement group the quarry beds have an aggregate thickness of from 5 to 12 feet, and the strata vary from 5 to 16 inches. Generally two or three men work together in a quarry, and some of the quarries are contiguous and admit of a common system of drainage. The amount of capital invested in this region is very small, as the quarrymen do not often own the land on which they quarry, but pay a rent, usually at the rate of half a cent per square foot for the stone taken out. Formerly a large amount of quarrying was done in this locality, but the increasing expense of working the quarries and the low prices for stone have reduced the extent of the industry. The work is now mainly done by men who have their own boys to assist them, and very few men are hired. In some portions of this region the dip of the strata is to the northwest, and in others to the southwest. From the quarries of the Dutch settlement the product is carted to Glasco, Ulster county, a distance of about 6 miles, and is there sold to dealers for flagging and edge stone.

The Hallihan's Hill series of quarries is on the same ledge as the bed of stone extending southwest from the Dutch settlement to the Sawkill creek for a distance of over 2 miles. At the southern end the ledge is quite elevated, but dips to the northwest and descends until it is lost. It is the extreme eastern one of the blue-stone belt, and immediately to the east of it the land descends to the low district extending to the Hudson. The bed worked in this ledge varies in thickness from 4 to 12 feet, and the cap-rock to be removed is from 4 to 30 feet in depth. The entire length of the ledge has been quarried over. The quarries now worked were opened, abandoned, and then reopened; most of them were left on account of the depth of stripping necessary when prices declined several years ago, and are worked now by the men who were unable to leave with their families when wages were low.

The Jockey Hill and Dutch Hill line of quarries is southwest of the Hallihan's Hill quarries and forms one continuous opening, and nearly the whole surface of the ledge has been quarried over. The strata are from 2 to 3 feet thick, and the quarry beds are separated by strata of hard blue-stone which breaks and splits irregularly. The joints are vertical, and the north and south system is very regular and continuous; the east and west system is less regular and not continuous. Excepting for its quarry stone this district is almost valueless; its surface is very uneven and broken, and covered with forest trees. The stone from this district, as well as from the Hallihan's Hill quarries, is carted to Wilbur, a distance of from 7 to 9 miles. The bed dimensions of the largest blocks obtained from these quarries are 20 by 15 feet, but the possible dimensions of blocks from the quarries are claimed to be 60 by 18 feet. Each quarry has from two to ten quarrymen, very few of whom are employed for wages.

The Stony Hollow group is near the Ulster and Delaware railroad, and is the last group on the belt passing from northeast to southwest through Kingston township. The quarries are small, and some of them are on old abandoned sites. The product is taken to Wilbur on wagons, a distance of 6 or 7 miles.

The quarries of Hurley township are in four principal groups. The Bristol Hill quarries are west of Stony Hollow on the southwest extension of the Stony Hollow line, on both sides of the Ulster and Delaware railroad, but the stone is taken by wagons to Wilbur, a distance of 7 or 8 miles. A large space has been quarried over in the thirty or more years in which the quarries have been worked, and the quarries are at present doing quite an extensive business. An excellent quality of stone, applicable to the finest kinds of work for which the North River blue-stone is used, is obtained here. The West Hurley quarries proper are northwest of Bristol hill, in a noted quarry center, where blue-stone has been taken out for forty years. The area worked over is large. The stone found here is remarkable for its evenness of stratification and regularity of jointing. The joint systems are at right angles to each other, the one running northwest being open and continuous, but the one to the northeast is less regular and interrupted in places. Some of the largest quarries of the blue-stone district are in this region. There is generally a lack of capital, and therefore a loss in efficient working. These quarries are on the line of the Ulster and Delaware railroad, but the rates of transportation by railway are so high that the stone is drawn on wagons a distance of 9 miles to the canal at Wilbur.

The Morgan Hill quarries are on the line running southwest from Stony hollow and Bristol hill. They are six in number, all of them quite small, and others in the same range have been abandoned. The locality known as Steenykill marks the southwestern limit of the main Hudson River blue-stone belt, which exhibits the same characteristic features throughout from Quarryville to the Esopus creek, in Marbletown township. Some small openings have been made in the formation just southwest of this creek.

The quarries to the northwest of this belt are, as already stated, in a higher formation. The West Saugerties range of quarries is west of Quarryville and near the foot of the Catskill mountains. Its structure resembles that of the Quarryville ranges, except that the layers are usually thicker. The principal joint system runs north 40° east, and the strata dip slightly toward the southwest. The overlying beds are shale and slate with interstratified beds of rough stone unfit for flagging or edge stuff. The West Saugerties stone has a medium grain and the characteristic color of the North River blue-stone. All the stone is carted to Malden, 8 miles distant, and here the heavier stone is manufactured for various architectural uses. It is quite soft and works easier than much of the North River blue-stone. In the Highwoods quarries the aggregate thickness of the quarry beds is from 4 to 10 feet, and the stripping varies from 4 to 23 feet. Heavy stones are also obtained here, and are cut into sills, caps, and other edge stuff at the yards at Saugerties, 8 miles from the quarries, and at Glasco, from 4 to 6 miles away. At one quarry the layers are from 20 inches to 3 feet in thickness, and a block now exposed is 220 feet long, 26 feet wide, and 1 foot thick. Blocks 25 by 15 feet by 1 foot have been taken from this quarry.

The quarries in the vicinity of Woodstock are on the southern foot of the Catskill mountains, and 1,000 feet above the Hudson river. The strata dip to the northwest, and in some of the quarries the bedding and jointing are somewhat irregular. The layers are usually from 2 to 10 feet thick; the aggregate thickness of the beds is about 20 feet; the stripping is mainly slate, and usually heavy. The product is carted to Saugerties, 11 miles distant, except from the quarries of Messrs. Elting & Maxwell and P. H. Lapo; these two quarries are northwest of Woodstock; the latter is farthest in the mountains, 1 mile northwest of Cooper's lake, and several hundred feet above it. The product of these quarries is carted to Malden, from 16 to 17 miles distant, and is used almost exclusively for cut work.

The Shandaken quarries are in a locality known as Fox hollow, a short distance from the Ulster and Delaware railroad, by which the product is shipped to Rondout, and thence by river to New York city. This stone has a gray color; the layers are from 10 to 12 inches in thickness, and large-sized blocks are easily obtained, but the material is not so much desired on account of its color as the typical blue-stone. There are only two quarries as yet opened on Woodland creek, and it is quite probable that the entire eastern bank, for a considerable distance, is bordered with ledges of sandstone suitable for building and flagging. The rock is of good quality and works freely. Two distinct grades are obtained; the upper part of the bed worked is of a reddish color and rather coarser in texture than the lower portion, which is grayish in color. The bed dips toward the valley, and as it is worked back into the mountain it rises so that the stripping does not increase rapidly. The bed has been worked to a depth of 18 feet and the bottom is not yet reached. The layers are from 2 to 12 inches in thickness, and increase in thickness with the depth of the quarry. Many of the quarries in the vicinity of Phœnicia have been opened quite recently. The amount of stripping in the Phœnicia quarries is about 20 feet, making the working of the quarries rather expensive, but the excellence of the stone and the large and heavy blocks to be obtained make the quarries profitable. The Ulster and Delaware railroad also furnishes cheap transportation.

The quarries near Brodhead are all west of Esopus creek, and from 2½ to 4 miles from the station. Nearly all the stone from these quarries is dressed at Brodhead, and thence shipped to market over the Ulster and Delaware railroad. This stone is of good quality, but there is a lack of capital to open workable beds. The aggregate thickness of the beds is from 4 to 11 feet, and the stripping from 4 to 14 feet, and in some places increasing rapidly.

As has been indicated, the blue-stone formation is traceable to the southwest from the Hudson River quarries through Rochester and Wawarsing, Ulster county; and occurs in Neversink, Fallsburgh, Mamakating, Thompson, Forestburgh, Lumberland, and Highland townships, Sullivan county; and in Deer Park township, Orange county. The Rochester and Wawarsing quarries are all small openings, and generally worked on leases, along the valleys of Vernoo, Beerkill, and Lackanack creeks, all tributaries to Rondout creek. At the quarries on Vernoo creek the beds dip at an angle of 20° to the north, 60° west, and the average inclination of the strata in this region is 20°. The stone is coarser grained in these quarries than in those nearer the Hudson, but is thought to be equally strong and durable. There are many abandoned openings in this region. All these quarries are small, and the workable beds are soon exhausted on account of the steep inclination of the strata. The quarries along Beerkill creek are not now in operation; they were worked quite vigorously for a time to supply Ellenville with stone for sidewalks—a town of about 4,000 inhabitants, which has 14 miles of stone sidewalk.

Along the Delaware river the flagging-stone belt is exposed from near Pond Eddy up the stream nearly 25 miles to Lackawaxen, Pike county, Pennsylvania. The principal quarries on the New York side are in the vicinity of Pond Eddy. From one of these two large flags were furnished, each 25½ by 15½ feet by 7 inches, and their width was limited only by the size of the boats which could go through the locks of the Delaware and Hudson canal.

These quarries on the Delaware river are noted for their excellent quality of stone. The strata are here again nearly horizontal, and from 1 inch to 1 foot in thickness, and the maximum amount of stripping is 10 feet. The product is mainly taken by canal to New York city.

The quarries along the valley from West Brookville, and those along the line of the Monticello railroad, in Mamakating and Forestburgh townships, Sullivan county, are usually small. Their total production has declined greatly within ten years. The West Brookville quarries are on the mountain side, several hundred feet above the canal-level, and all the stone is carted to the canal at West Brookville. Some of this stone has a reddish color, and is said to be stronger than the Ulster County stone; but the market prices are higher for blue-stone, and there is a prejudice against red or gray shades of color. Along the Monticello branch of the Lake Erie and Western railroad there are numbers of small quarries, all of which open into steep side hills, and have a rapidly-increasing amount of stripping.

There is a great number of small openings in this region which have been abandoned. The amount of stripping is always considerable, and the aggregate thickness of the quarry beds is small and the layers are thin. The stone has the color of the Hudson River stone, but it is very hard, and none of it is equal in quality to that obtained in the Hudson River quarries. A new flagging-stone district has been made accessible to the markets by the New York, Ontario, and Western railroad, running across Sullivan and Delaware counties, and stone is being shipped both eastward and westward. The business was insignificant during the census year.

In Delaware county the flagging-stone quarries are along the lines of the New York, Ontario, and Western and the Ulster and Delaware railroads. All these quarries are probably in the Catskill group. The quarries at Westfield flats and near Trout Brook and East Branch are near the New York, Ontario, and Western railroad. The stone is a rather coarse grained sandstone or grit of a grayish to a greenish-gray color, thus differing from the darker and finer-grained blue-stone of the Hamilton formation. Various openings have recently been made in this region along this line of railroad.

At a quarry near Margaretville the depth of stripping is 8 feet, and the blocks, as limited by the natural joints, are very large. The product is carted to Hartville station, on the Ulster and Delaware railroad, and from there transported by rail to Rondout. A quarry has been opened near Halcottsville. The beds here so far as developed are from 1 inch to 4 inches thick and the depth of stripping is 8 feet. The joints are vertical and very regular; the stone is reddish in color and rather coarse grained; blocks 15 by 6 feet have been taken out, and larger sizes might be obtained.

The quarries in the vicinity of Roxbury are also near the line of the Ulster and Delaware railroad. In a quarry about 1 mile from Grand Gorge station, 70 miles from Rondout, the workable beds are 12 feet in thickness and the depth of stripping is about 30 feet. The stone has a grayish color and is coarse grained.

In Otsego county both the Hamilton and the Chemung groups are quarried in a quarry located on the east side of Otsego lake and about 70 feet above it. The jointing is rectangular, the beds are even, and the depth of stripping is 8 feet. The stone is soft, works easily when first quarried, and hardens on exposure. Where used for steps for a number of years it has not worn smooth, and shows considerable durability. At present this quarry supplies only the local demand for foundations and general building purposes.

The quarry at Oneonta supplies the local demand for flagging and cut work.

In Chenango county there was formerly quite an extensive quarry industry at Guilford, but at present only one quarry is in operation. The market for this stone is at Syracuse. Blocks of large bed dimensions may be obtained here, but the layers are rather thin. The quarry at Smithville flats is also remarkable for the large size of the blocks between the joints, and some of the layers are 2 feet in thickness. The aggregate thickness of workable beds is about 12 feet, and the depth of stripping is about 15 feet, but it is mostly loose material and easily removed. The stone is shipped principally to New York city for flagging and building purposes; but it has to be drawn on wagons to Greene, 8 miles distant, on the Utica division of the Delaware, Lackawanna, and Western railroad.

In Oneida county the Oneida conglomerate quarried near New Hartford is hard and difficult to dress, and therefore is used only for bridge work and foundations. The quarry at Camden is probably in the Medina sandstone, but the formation has not been well identified. The stone is light gray in color and rather coarse grained; the layers near the surface are thin, and are used for flagging, but they increase in thickness as the quarry is worked downward. The stone is used to supply local demands, and some is shipped to Oswego and neighboring towns.

The quarry near Atwater, Cayuga county, is in a good flag-stone stratum, but its distance from the nearest railway station and the depth of cap-rock to be removed prevent its extensive development.

The Tompkins County quarries are worked chiefly for flagging. The quarry at Ithaca supplies the local demand, and the one at Trumansburg supplies flagging for the town of Geneva and some for Ithaca. The layers in these quarries are rather thin, but large blocks can be obtained. The quarries at Covert, Seneca county, also furnish flagging, which is at present used mainly at the towns of Geneva, Waterloo, and Auburn. The quarries are located but a short distance from railroad and water transportation.

The quarry at Watkins, Schuyler county, is a fine-grained, evenly-bedded blue sandstone. The stone is used along the line of the North Central railroad for general construction purposes, and it seems to be well adapted for

heavy bridge construction. No good building stone is found on this line of railroad either north or south of this point for a considerable distance, and the stone from this quarry is used southward on the railroad as far as Williamsport, Pennsylvania.

The Steuben County quarries furnish stone for general building purposes, mainly for local demands. The stone dresses easily, but it is not a safe stone to use, because it is liable to disintegrate. The demand in this county for good stone is supplied from distant quarries, and flagging has been furnished quite largely from Mainsburg, Tioga county, Pennsylvania.

The quarry district in the Medina sandstone extends from Brockport, Monroe county, to Lockport, Niagara county. The stone is very hard, and therefore seldom used for cut work. There is a light gray and also a reddish variety, the latter has a bright and pleasant appearance both in dressed and in rock-faced work, and both varieties are sometimes used together with good effect, but the red is used more than the gray for buildings. Most of the stone buildings in Lockport and in Buffalo are of Medina sandstone. Perhaps the most important feature of this stone is its special applicability for street pavements. It was first introduced for this purpose in Cleveland, Ohio, and it is now used in many cities and towns from New York to Kansas City. The blocks are made of the same size and shape as the granite paving blocks; they do not wear smooth, and are nearly, if not quite, as durable as granite blocks. The stratum of quarry rock is about 30 feet in thickness, and the thickness of the layers varies from 2½ to 18 inches, the thinner ones supplying an excellent material for paving sidewalks.

The remaining quarries in the state of New York are small and supply local demands. The stone is of an inferior quality, except in the Belfast quarry, Allegany county, where it is of good quality, though so far from any route of transportation that it cannot be worked for anything but local use.

MARBLE.

TUCKAHOE MARBLE.—The quarries which furnish this are, according to Newberry, in one of the belts of dolomite of Archæan age which lie to the north of New York city, and cross the country in a north-northeast direction. One of these belts reaches New York island, crossing the Harlem river at Kingsbridge; another crops out on the sound near Rochelle; others strike the river at Hastings, Dobbs Ferry, Sing Sing, and other points, and furnish stones good for construction purposes and of varied colors. The best marbles obtained from these deposits are those of Tuckahoe and Pleasantville. The first is white, rather coarse in texture and regular in quality, and the better grades have been used for some of the finest buildings in the city of New York, notably Saint Patrick's cathedral. The color changes to light gray by exposure.

At the quarry of the Tuckahoe Marble Company the finest grade is nearly a pure white, but this is available only in small quantities, and is used for monumental and ornamental work. In Mr. John F. Masterdon's quarry this same material is quarried more extensively.

In composition the stone from these quarries is a dolomite, containing a small amount of iron and some mica. The buildings constructed of the stone from the Tuckahoe Marble Company's quarry are those of the New York Stock Exchange, New York city, and the Mutual Life Insurance Company at Boston. Those constructed of the material from Mr. Masterdon's quarry are the New York Life Insurance building, New York city, the city hall, Brooklyn, New York, and the hotel Vendôme, Boston.

At Pleasantville, a few miles north of the Tuckahoe quarries, a coarse, crystalline white marble occurs; formerly this was quite extensively quarried for building purposes. The front of the Union Dime Savings Bank building in New York city is built of this stone. Its structure being quite coarse, it is not well adapted for carved work. It has also been found to break easily, especially when used for long columns; and it would not be a safe stone on this account for all kinds of work. The stone is remarkable for its crystalline appearance, the crystals being usually large and conspicuous, and, from this peculiar appearance, it has received the name of "snow-flake" marble. This quarry has recently been furnishing about 25 tons of stone per day for making soda water.

At Dover Plains and South Dover are three other marble quarries, the stone from which also shows a coarse structure and is easily broken.

A quarry of bluish-gray limestone was opened in November, 1880, at Clinton Point, about 5 miles south of Poughkeepsie. The material that has been extracted has been used for bridge abutments at Newburgh.

At Greenport, Columbia county, Mr. F. W. Jones' quarry is worked on a stratum from 60 to 70 feet in thickness. Blocks of any desired dimensions may be obtained. The stone is employed for general architectural and ornamental uses, principally at Hudson and Troy, New York. The Presbyterian church at Hudson is constructed of it. It is a nearly pure limestone, containing some protoxide of iron and a little magnesia. The quarry of the Kingsbury Blue Stone Company at Sandy Hill, Washington county, is located on a branch of the Champlain canal and near the railroad of the Delaware and Hudson Canal Company, and has superior facilities for transporting the material to market both by canal and by railway. The quarry proper covers an area of 40 acres. A face half a mile in length and 30 feet in height is opened. The stone is very nearly a pure limestone, containing a very small amount of iron, a little magnesia, and a little siliceous matter. It was used in the construction of most of the locks upon the Champlain canal and the city dam at Cohoes, and it is now being used for the construction of the Harlem bridge for the West Side and Yonkers Elevated railway.

The quarry of Mr. Prince Wing, near Saratoga, has been worked for many years, stone for burning lime having been taken out before 1800. The lime produced from it is very white and of excellent quality. In composition it is almost a pure limestone, containing very little magnesia and some graphite. It is used for general building purposes and for flagging, mainly at Saratoga and Ballston, New York.

The quarries at Glens Falls are worked on both sides of the Hudson river, which breaks through the formation at this point. The same formation crops out a short distance east of this place, is crossed by the river, dips under the overlying formation, and disappears just above the falls. On the south side of the river there are three distinct strata of limestone; the upper one, about 12 feet thick, being overlaid by about 15 feet of rough limestone and some slate. It is fine-grained and makes a good material for cut work. Below this is a stratum of about 15 feet of the slaty-structured stone, and then a stratum 2 feet in thickness of a coarse crystalline limestone. Below this occurs the valuable black-marble bed, about 12 feet in thickness. From this a large amount of tiling is manufactured. The stone is taken out in large blocks, and is either sawed and rubbed in the mills at the quarry or is shipped in the rough, mainly to the neighboring cities and to New York. The tiling and material for ornamental purposes go to all the principal cities in the United States. The stone is shipped both on the Champlain canal and the Delaware and Hudson Canal Company railroad. It is a limestone in composition, containing a little magnesia, some iron, and some graphite. None of the products of the lower stratum are allowed to go to waste, though a very large proportion of the material is not suitable for architectural or ornamental work. A large amount of the marble of the lower bed on both sides of the river is burned in the extensive kilns of the Glens Falls Company, and produces the so-called "Jointa" lime of remarkable purity. The stone is quarried by blasting, and, therefore, much of it is shattered so as to be fit only for burning. The slaty-mixed limestone of some of the layers and of the stripping was formerly used for flux in the iron furnace at Fort Edward, New York.

On the north side of the river, where the quarry of the Glens Falls Company is located, the two upper strata above mentioned do not occur. The formation has here been worked to an average depth of about 30 feet and 60 feet in width for a distance of half a mile eastward from Glens Falls.

The next point to the north of Glens Falls where the Trenton limestone is quarried is at the quarry of Mr. Frank Clark, near Crown Point, Essex county. In general appearance and composition this stone resembles that of Glens Falls, but its texture is finer and more brittle. It is used for curbs, trimmings, and various kinds of cut work, principally at Fort Henry, Plattsburgh, Saratoga, and Schuylerville. The rock is considerably fractured, and large blocks suitable for sawing cannot be readily obtained.

Of the marble and limestone deposits on the west shore of Lake Champlain only two localities have been extensively developed, one at Willsborough, Essex county, and the other at Plattsburgh, Clinton county. The quarry of the Lake Champlain Quarry Company is located on the extreme northeast portion of Willsborough point; it is well equipped and favorably located, the blocks being swung by derricks directly from their beds to the decks of the boats used for transporting the material to market. The stone is, for the most part, a fine-grained, compact, blue limestone, containing fossil remains; the different layers differ slightly in color and texture. Formerly a large amount of this stone was shipped, but during a few years past the demand has been much lighter. It was used in the foundations of the piers of the East River bridge, and in the foundations of the new capitol at Albany. There are several layers worked which are separated by thin seams of clay; large-sized blocks can be obtained, and the stone is worked into all kinds of cut work and can be sawed and rubbed. Some of the layers furnish a fine black marble, which is susceptible of being highly polished, and it is used for various kinds of ornamental work. The rock comes to the surface and no stripping is necessary. The formation dips east of north under the lake. A porphyritic dike crosses the formation from east to west; it is from 12 to 14 feet wide and exceedingly well marked, extending from the shore of the lake until lost beneath the soil beyond the quarry.

The quarry of the Burlington Manufacturing Company is located near Lake Champlain and not far from Plattsburgh. Large blocks are channeled out and shipped by boat to Burlington, Vermont, where they are sawed, and from the slabs all kinds of ornamental work are produced. Two varieties of limestone occur at this point, and are known in the trade as French-gray and Lepanto marbles. The latter is beautifully variegated with red and gray, and is largely made up of fossil remains, which give a beautiful appearance to a polished surface. The variegated marble is quite extensively used for inside decoration in public buildings, often in connection with white marble. It is shipped, for mantels, tiling, table-tops, and general decorative work, to all parts of the United States. Another marble quarry has recently been opened by this company at Fort Henry, Essex county. This marble is composed of a ground mass in which are patches of serpentine, numerous crystals of pyrrhotite about one-eighth of an inch in diameter, and some graphite scales.

The quarry of the Gouverneur Marble and Whitney Granite Company is situated one mile west of Gouverneur, Lewis county. The limestone is crystalline and lies immediately on the granite; in fact, in some places the granite overlies the limestone. The surface is glaciated and rubbed smooth. It is usually called "Whitney granite", on account of its close resemblance to several kinds of gray granite when polished or finished with a patent hammer; but it is properly a marble, being, however, too coarse-grained to be finely carved. There is reason to believe that it will withstand the action of the weather, as head-stones in this immediate vicinity have been standing from 40 to 70 years. In the Riverside cemetery at Gouverneur there are about one hundred of these

old head-stones; they present a good, clean, uniform surface, are very free from moss or any discoloration, and the corners and arrises are sharp and perfect. This marble is easy to work and takes a very fine gloss, and, being dark colored when polished and white when chiseled, any scroll-work or tracing makes a nice contrast. Much of it is finished with a patent hammer, some partly patent-hammered and partly polished, or polished and margined.

On account of the thickness of layers in the quarry, dies can be furnished 7 feet high that will stand on their natural bed and be of good uniform color. All dies 18 inches square or over are quarried to stand on their natural bed. Smaller sizes are quarried the other way.

The entire limestone formation is marketable stone, and there is no cap-rock to be removed. The upper portion, which is coarsely crystalline, is used for building purposes. Farther down the grain is finer and the color darker, and most of this is shipped directly to Cleveland, Ohio, and to New York city, where it is sawed and manufactured.

In this locality there are several quarries of the same stone now being opened. An excellent quality of granite is also found here, but as yet has not been worked. Soap-stone is also found in workable quantities, and asbestos appears. A large variety of serpentine is found in this locality, though as yet none has been put into the market.

A quarry at the head of Three-Mile bay, Jefferson county, is favorably located for water transportation. The rock is a rather hard, compact limestone, but works quite well for fine cut work. Two varieties, blue and gray, are used. Several quarries have been opened in the same formation at Chaumont, a few miles from the Three-Mile-Bay quarry, and on the Rome and Watertown railway.

A quarry at Lowville, Lewis county, in the cliff of Trenton limestone caused by Mill creek cutting across the formation at this point, has a face of nearly 90 feet, which is almost the entire thickness of the blue limestone in this section. It furnishes an excellent building stone, for local demand mainly, and also stone for flagging and curbing.

A quarry in a gorge through which the Sugar river passes, at Talcottville, Lewis county, can be worked with the least possible amount of labor and expense. The stream has cut through the ledge and left cliffs of solid stone 30 or more feet in height in an exposure of a quarter of a mile or more. All of this is valuable stone. The top layers are used for lime and the lower ones for building stone. The layers are from 3 to 15 inches thick, and furnish an excellent working stone, making good cut work. Between the layers of stone are thin layers of slate. Marine fossils are found in abundance. Formerly large amounts of stone were sent from this quarry to the towns along the Utica and Black River railroad, but at present the building-stones taken out are used in the county. The jointing of the formation at this point is remarkably regular, and the layers of the bed are free and easily separated. No other quarries of any importance are opened in this vicinity.

At Canajoharie, Montgomery county, an extensive ledge of Trenton limestone occurs south of the Mohawk river. Quite a variety of stone is obtained in the different layers in the quarry worked at this point. The topmost layer is a hard, rough, somewhat calciferous sand-rock, and below this is a gray rock, gray limestone, etc. The layers vary in thickness from 2 feet downward. Only the gray limestone is dressed, and the sand-rock is used quite largely for foundations; a number of the houses in the town of Canajoharie are built of it. The stone from this quarry is also shipped to Utica and Little Falls; at the former place it was used in the construction of the steam cotton-mills and the Mohawk River Valley mills. Farther down the Mohawk river, at Tribes Hill, the Trenton group is partly cut through, and valuable building stones are obtained on each side of the stream. The quarries here produced in former years much of the stone used in the construction of bridges on the New York Central and Hudson River railroad, and much of that used in building the locks of the Erie canal. The locations of these quarries are convenient for transportation, those on the north of the river being on the line of the New York Central railroad, and those on the south on the canal banks. The stone is strong, compact, and durable, and is little affected by atmospheric action, though some of the strata which occur here are not valuable for building stone. At the top occurs a shell limestone; below this a stratum of gray limestone about 4 feet in thickness, then a dark blue limestone 7 feet in thickness, then a stratum, about 4 feet in thickness, of rough, hard, flinty sandstone, somewhat calciferous, and below this is the stratum which furnishes the best stone. This last has been worked to a depth of 28 feet, and the bottom has not yet been reached.

About 1 mile north of Amsterdam, Montgomery county, there are two distinct strata of stone quarried, differing in color and quality, that of the upper stratum being quite largely burned for lime, and also used for cut work; the lower stratum is more brittle. The layers are from 4 inches to 2½ feet in thickness; the weathered portion of the top is burned. Most of the product of these quarries is used to supply local demands, though some of it has been shipped for use in important structures, including the New York Central Railroad bridge at Albany, the Cohoes dam, and the state capitol.

At Sharon Springs, Schoharie county, is a dark-colored, firm limestone, in beds varying in thickness from a few inches to 2½ feet. The thin beds are used in the vicinity for paving sidewalks. The stone, though quite hard, dresses easily, and is used for general architectural purposes, though mainly to supply the local demand. This quarry has been worked at intervals for many years past, but during the last eight or nine years it has been worked but little, though the stone is of superior quality, and might form the basis of an extensive industry with sufficiently low rates of transportation.

Near Cobleskill the Corniferous formation occurs in strata of cherty limestone, and gray and blue limestone, separated by layers of chert nodules. The stone dresses quite well, and is used for buildings and monumental work.

Just south of Howe's cave there is a high cliff of limestone of the Lower Helderberg formation, in which the quarry of the Howe's Cave Association is located. The total height of the escarpment above the valley bottom is about 150 feet. The vertical section of the quarry is as follows:

	Feet.
Gray stone, used for heavy work	15
Gray and black stone mixed, used for ballast	12
Blue limestone—building stone	10
Shaly beds, used for ballast	10
Blue limestone—building stone	6

The heavy gray limestone is taken out in large blocks and is used chiefly for the construction of bridge abutments. It is not susceptible of being polished and is not well adapted to fine work. The blue limestone dresses well, and the material readily finds market along the line of the Albany and Susquehanna railroad. A considerable quarry industry has been built up at this point, owing to the excellence of the stone, especially for heavy masonry, and to the convenience in working the quarry due to the slight amount of cap-rock to be removed, the height of quarry face, and natural drainage. There is also an advantage gained from the fact that the material which, for one cause or another, is not suitable for building stone is broken up and used for railroad ballast.

The Onondaga limestone occurs in beds from 1 foot to 2½ feet in thickness. One mile north of the village of Springfield Center, Otsego county, on the west side of the outlet of Summit lake, the quarry of Messrs. McCabe & Brothers is located. The top of the limestone is polished and grooved by glacial action, and is covered by from 15 to 30 feet of glacial drift. This covering of clayey and calcareous drift has protected the stone against atmospheric influences, and no discoloration has taken place. The rock has a bluish color, which on exposure becomes somewhat lighter. The massive character of the stone makes it suitable for heavy work, and it also seems to possess the properties of strength and durability; however, no examples are known where the stone has been exposed for a very long time to test its power of endurance. Several buildings have been constructed of it, including the Otsego County jail, and the hotel Fenimore, at Cooperstown.

In Onondaga county the Onondaga limestone was formerly quite extensively quarried, during the period of the rapid development of the country. The quarries at Onondaga are within the Indian reservation, and furnish an excellent quality of stone; but the amount of cap-rock to be removed is considerable, being from 16 to 18 feet, and the lack of facilities for transportation prevents an extensive quarry industry. The stone is used for buildings and monuments chiefly at Binghamton and at Syracuse; in the latter place the university building, the court-house, and Saint Mary's church are built of this stone.

The quarries at Fair Mount and Manlius were first opened to obtain stone for locks on the Erie canal. In this vicinity there were formerly also a greater number of quarries than at present, and the demand for the stone is still gradually diminishing. The beds are not so heavy as those at Onondaga; they are here from 8 to 12 inches thick, and at Onondaga some layers are 4 feet in thickness. Fine exposures of the Tully limestone also occur in some localities, but it is not found in places where facilities for transportation are afforded, and has therefore not been at all developed.

The quarries at Auburn, Cayuga county, supply the local demand for general construction purposes, and some of the gray limestone from the quarry of Mr. John Bennett has been used for monuments. Some quarries are also worked in the vicinity of Auburn for stone used in macadamizing roads, and some for lime. The rock is nearly a pure limestone, containing a little magnesia and iron.

At Union Springs the Seneca blue limestone is quarried principally for railroad work along the line of the Delaware, Lackawanna, and Western railroad. The stone is suitable for bridge construction and other heavy masonry in which undressed stone may be used, the beds being even, some of them 20 inches in thickness, and the blocks being readily broken out in rectangular shapes. This limestone contains little magnesia, some graphite, and some protoxide of iron.

A favorable development of the Onondaga limestone occurs at Waterloo, Seneca county, on the Erie canal. The quarries at this point were opened when the canal was built, and have been worked more or less ever since. The stripping is from 5 to 8 feet, and the limestone has been quarried out to a depth of from 18 to 22 feet. The stone is used chiefly at Rochester for general construction purposes. At Rochester the Niagara limestone occurs in broken strata and is quarried for rough foundations. The stone is easily accessible, being covered with only 2 feet of loose material, and conveniently supplies the local demand for foundation stone.

At Le Roy, Genesee county, the Onondaga limestone is quarried for the Elmira market, chiefly for foundations and for bridge work on the Erie and State Line railroad. The stone is too hard to dress, and is used only for rough masonry. Some stone has also been quarried in this vicinity for blast-furnace flux.

At Lockport, Niagara county, the Niagara limestone has been quite extensively quarried for many years for general construction purposes, and the stone has been shipped to New York, Buffalo, and Rochester. In some years the value of the product sold has reached \$400,000, but the demand for this stone has diminished in the last few years. The quarry is favorably located for transportation both by canal and by railroad.

The corniferous limestone crops out quite extensively in the vicinity of Buffalo and within the city limits. The quarries at Williamsville, about 10 miles northeast of Buffalo, are worked for the Buffalo market, producing material for ordinary purposes of construction, and some stone suitable for sawing and polishing, which is manufactured for ornamental purposes, principally table-tops and mantels. The Buffalo quarries supply most of the stone for rough masonry, such as cellar walls, foundations, cribs, piers, and general railroad work in the vicinity of Buffalo. It is not adapted to cut work.

A number of quarries which do not appear in the tables are worked at intervals in this vicinity. The deepest of the quarries have been excavated about 30 feet in depth, and several acres in area have been taken out. A considerable amount of lime is manufactured in the quarries of the corniferous limestone in Erie county. The rock is nearly pure limestone, containing small quantities of magnesia and iron, and very little siliceous matter.

NEW JERSEY.

[Compiled mainly from notes by Professors Cook and Smock.]

ARCHÆAN GRANITE, GNEISS, AND MARBLE.

The gneisses make up the great mass of the Archæan outcrop. The areas of granite and of crystalline limestone are comparatively small, and are confined to the highlands in the northern part of the state, in Sussex, Warren, Morris, Hunterdon, Passaic, and Bergen counties. The Morris canal, the Delaware, Lackawanna, and Western, the Central New York, the Susquehanna and Western, the New York and Greenwood Lake, the Belvidere Delaware, and the Sussex railroads all traverse the district. The New York, Lake Erie, and Western and the new Lehigh and Hudson railroads also run close to outcrops of these Archæan rocks. The facilities for easy transportation to large cities and towns are good.

The beds of gneiss are in many places very regular, and the stone is generally free from pyrite, magnetite, or other injurious constituents; but care is necessary to avoid these minerals, as they are found widely distributed. Granite is not common, except in small masses, and the outcrops are too limited for quarrying.

LOCALITIES WHERE GRANITE QUARRIES HAVE BEEN OPENED.

1. Near Franklin Furnace, Sussex county. *Geology of New Jersey*, p. 503.
2. Port Murray, Warren county. *Geology of New Jersey*, p. 503.
3. Dover, Morris county. *Geology of New Jersey*, p. 502.
4. Bloomingdale, Passaic county. *An. Rept.*, 1873, pp. 99, 100.
5. Near Charlotteburg (granite), Passaic county. *An. Rept.*, 1873, p. 100.

MARBLES.

1. Warren Marble quarry, Warren county. *An. Rept.*, 1872, p. 26.
2. Marble mountain, Warren county. *An. Rept.*, p. 28.
3. Rose Crystal Marble quarry, Warren county. *An. Repts.*, 1872, p. 27; 1881, p. 42.

A white limestone has been quarried near Stanhope, in Sussex county, but without much success, as the mass appears to be traversed by seams.

REFERENCES TO GENERAL DESCRIPTIONS OF GNEISS LIMESTONE.—*Geology of New Jersey*, 1868, pp. 64, 312, 316, 319, 321, 502; *An. Rept.* for 1873, p. 101; *ibid.*, for 1881, pp. 41, 42; *ibid.*, for 1879, p. 104 (Mendham limestone).

The only locality in New Jersey where gneiss has been quarried uninterruptedly for any considerable period is at Dover, Morris county, on the Delaware, Lackawanna, and Western railroad. The material is quarried for bridge construction and general work for the railroad company's use exclusively. Quarries in the other gneissic-rock localities in the state have all been abandoned after short periods of working. The convenient location at the side of the railroad track, the very light stripping, the facility with which the stone can be quarried, and its excellence as durable and solid stone for heavy work make this quarry a profitable one. The direction of the outcrop is northeast, and it is cut by the new High Bridge railroad a few rods from this quarry.

The New Jersey Central Railroad Company proposes to open a quarry near the railroad in the same hill. With the two lines of railroad and the Morris canal, all crossing the ledges, the transportation facilities are unsurpassed. The great amount of stone which can be obtained in the clearing of ground for agricultural purposes in this neighborhood and in northern New Jersey generally has retarded the development of quarries in the gneissic rocks of this part of the state. As the country becomes more cleared and the land more valuable, these sources of supply are gradually restricted and other quarries similar to the Dover quarry will be developed. For ordinary foundation work and for cellar walls, bridges, wharves, and work of that class, the supply is inexhaustible, and stone can be furnished at comparatively low rates. The use of the gneissic rocks of New Jersey is increasing, as they are excellently adapted from their strength and durability to many purposes.

POTSDAM SANDSTONE AND GREEN POND MOUNTAIN CONGLOMERATE.

The sandstone considered of Potsdam age occurs in narrow outcrops bordering at intervals the gneisses. For localities see *Geology of New Jersey*, pp. 71-79. A little less has been quarried at (1) Franklin Furnace, Sussex county; (2) Danville, Warren county; (3) Oxford Furnace, Warren county; and (4) in the Pohatcong valley, near Washington, Warren county.

The sandstone of the Green Pond mountain belt (of Potsdam horizon) has been quarried on Kanouse mountain (near) 1, Newfoundland, Passaic county; (near) 2, McCainsville, Morris county.

REFERENCES ADDITIONAL TO ABOVE.—*Geology of New Jersey*, pp. 503, 504; *An. Rept.*, 1872, pp. 28, 29; *ibid.*, 1881, p. 42.

The Green Pond mountain conglomerate has been used with good effect at Morristown and at Boonton, but the bowlders of the country around the towns have furnished an adequate supply. The same stone can be obtained at many places in Morris and Passaic counties. It can be had in blocks of any size capable of easy handling. The stone is very hard and solid, and free from all minerals other than quartz; and the sharp, angular edges and numberless glacier-polished bowlders which have been exposed to the weather for ages attest its ability to resist atmospheric agencies; but it is not easy to dress on account of its excessive hardness. The quarries in this formation were not in operation during 1880.

MAGNESIAN LIMESTONE.

This rock is the predominating limestone of the state, and is found in Hunterdon, Warren, Sussex, Morris, and Somerset counties. For the localities see *Geology of New Jersey*, pp. 9-130; also map. It has been opened at many points for stone to be used in lime manufacture. For building purposes the localities in which this stone is found are numerous, particularly in Sussex and Warren counties; and it is in general use in these counties, and in parts of the adjoining counties of Hunterdon, Somerset, and Passaic, for building foundations, and for buildings of all kinds. For heavy bridge work it is used largely. The railroad and canal companies use a great deal of it in heavy construction. (See *Geology of New Jersey*, pp. 513, 514 and 392-396; *An. Rept.* for 1873, pp. 100, 101; *ibid.*, 1881, p. 41; also schedule of Newton limestone.) For analyses see above references and *An. Repts.*, 1875, p. 36; 1876, p. 55; 1878, p. 104.

HUDSON RIVER SLATE.

This rock yields the roofing slates. The principal quarries are: (1) La Fayette, Sussex county; (2) Newton, Sussex county; (3) Delaware Water Gap, Warren county.

REFERENCES.—*Geology of New Jersey*, pp. 135-145 and 518-520; *An. Rept.* for 1872, pp. 29, 30. The flagging stone of Flag-stone hill, Wantage township, Sussex county, belongs to this geological horizon. *Geology of New Jersey*, 1868, p. 522: Flag-stone; *An. Rept.*, 1881, pp. 64-66.

The only quarries of roofing slate in New Jersey that were operated to any considerable extent in 1880 are those near La Fayette, Sussex county. They are within a mile of the Sussex railroad, and but little farther from the new line of the New York, Susquehanna, and Western railroad. These quarries dip to the northwest. The geological horizon is that of the Hudson River slate. The reputation of the La Fayette slate is good; the color is usually a blue-black.

ONEIDA CONGLOMERATE AND MEDINA SANDSTONE.

These rocks constitute the mass of the summit and western slope of the Kittatinny or Blue mountain, stretching from the Delaware Water Gap to the New York state line. They have not been opened by any regular quarries, although the outcrops are many and the stone of the conglomerate formation is solid and durable, and can be had in quite regular beds. The sandstone is, in most places, too slaty and shaly in structure to make a good building material. The only quarry or opening worthy the name is in Sussex county, and in Montague township, where the red stone is got out in thin beds of large size; but it is not near transportation. (*Geology of New Jersey*, 1868, pp. 146, 149, 513.)

LOWER HELDERBERG LIMESTONE GROUP.

The rocks of this group are found in place in a narrow belt in the valley of the Delaware from near Port Jervis to the Nalpack bend, and are confined to Sussex county alone. They are quarried extensively for lime manufacture, but not for building, except a little which goes to Port Jervis and the adjacent country. The quarries are in Montague township, Sussex county.

UPPER HELDERBERG GROUP—ONONDAGA AND CORNIFEROUS LIMESTONES.

The above-mentioned belt in Sussex county is bordered on the west and northwest by the very narrow belt of Oriskany sandstone and Cauda-galli grit (both unfit for building material), and these latter are followed by the Onondaga and Corniferous limestones in a very narrow outcrop bordering the alluvial plain of the Delaware river.

They have yielded considerable stone for this part of the Delaware valley, which is used for bridge piers, abutments, dwellings, etc., but there are no large and regularly-worked quarries. The outcrops are many, and no excavation is generally necessary to meet the occasional demands of the valley.

REFERENCES.—*Geology of New Jersey*, 1868, pp. 165, 166, 514.

TRIASSIC AGE—SANDSTONE, FREESTONE, AND BROWNSTONE.

The most noted quarries in the state and some of the largest in the country are opened in the sandstones of the Triassic age. The formation occupies a broad belt of the state, running from the New York line southwest to the Delaware river. Its boundaries are shown by the geological maps of the state. For general descriptions of its rocks, see *Geology of New Jersey*, 1868, pp. 206-225; also *An. Rept.* for 1879, pp. 18-35.

The Little Falls, Paterson, Belleville, and Newark quarries are the most celebrated of any on the eastern side of the state. In the central part of the belt there are quarries in Washington valley (north of Plainfield), at Martinsville and Princeton.

Along the Delaware river there are large quarries at Greensburg, 4 miles above Trenton, and farther up the river valley at Stockton and Prallsville. The localities where quarries have been opened are given in the *Annual Report of the New Jersey Geological Survey* for 1879, pp. 21, 25. There are other places where stone has been quarried, but the above list includes those which have been worked for sale of stone.

The principal building stone in Newark, Paterson, Orange, Elizabeth, and New Brunswick comes from the Belleville and Newark quarries. They furnish a large quantity of very superior building stone to New York city. The new Mills building in that city is one of their monuments. Trinity church, New York, represents Little Falls. In beauty of shade, solidity, and durability the selected stones from the Little Falls, Belleville, and Newark quarries are unsurpassed. It is not so micaceous as many other sandstones, and has not their laminated structure; hence for ornamental work it is well adapted. The absence of bedding lines admits of less care in laying it up. Some horizons are more argillaceous, and so-called "clay-holes" are observed in them.

The Belleville quarries are at North Belleville, and on the right, or west, bank of the Passaic river. They are located on a nearly north and south line, and are about 100 yards distant from the river front, which affords wharfage room for vessels of moderate size, as the tide comes up to this point. The railroad line (Newark and Paterson branch of the New York, Lake Erie, and Western railroad) runs nearly parallel with the river and about a quarter of a mile west of the quarries. There are three different openings. The following are some of the principal buildings in which this material has been used: Fort La Fayette, New York harbor; Stevens' house, Fifth avenue and Fifty-seventh street; Ruppert's house, Fifth avenue and Ninety-third street; building corner of Madison avenue and Twenty-eighth street; the Mills building, on Broad street, and A. T. Stewart's buildings, New York city.

There is considerable variation of the strata in the different parts of the quarry. In the southernmost of these quarries the glacial drift is 20 feet thick; then there is a thickness of 30 feet of red, fine-grained sandstone, most of which is of inferior quality, and the best of it is only fit for foundations, cellar walls, etc. Under this thickness comes next a coarse-grained, thickly-bedded, reddish-gray sandstone; beneath the latter is a fine-grained red sandstone, which can be rubbed and polished. The reddish-gray stone is equally durable, and looks well, but it cannot be rubbed. The former brings \$1, the latter \$1 50 per cubic foot. Explosives are used mostly for throwing down the top stone. Canisters or conical charges of black powder are always employed in working off blocks of the best and most valuable stone. There are disadvantages of considerable stripping. Working in the direction of the dip, water must be pumped out, as all of the quarries are below tide-level in the deepest points, one of them being 35 feet below the Passaic River level (tide).

Near Avondale station, Belleville, is a quarry of this material which was opened about the time of the Revolution. The principal markets now are Newark, New York, and Brooklyn. The ledge here extends S. 5° W., the strata being vertical. At the west end of the quarry there is a fine-grained chocolate-colored stone at the top, under several feet of stripping. The light-colored stone is a coarse, granular mixture of quartz and feldspar. The shade of color is very pleasing and the stone is solid, occurring in thick beds. It was used in the construction of the Presbyterian church, Fifth avenue and Fifty-fifth street, New York city, and of various bank buildings in Newark.

In one of these quarries the total area of the opening is at least 5 acres, being about 500 feet square. The vertical section on the northwest includes 60 feet of stripping, of which one bed 3 feet thick can be used for cutting into stone for foundations and cellar walls. Then there are 20 feet of the thick and solid beds of grayish, coarse-grained stone at top, and fine red stone used for rubbing at the bottom; underneath the latter there is an excavation 14 feet into a shaly rock. These varieties are sometimes designated "No. 1" and "No. 2" stone, respectively. On the south side of the quarry there are only 20 feet of stripping, and then comes solid stone. A fault traverses this quarry in a north and south direction, displacing the beds to the extent of 4 or 5 feet. Its plane dips 65° to 70° west. This fault also appears in one of the neighboring quarries.

On the south side of Bloomfield avenue, Newark, is located one of the principal quarries. The opening is at least 400 feet long from north to south, and the quarry progresses west and northwest in the line of the dip. The

stripping consists of earth and shaly rock, and varies in thickness from 10 to 30 feet. The dip is very uniformly in a west-northwest direction and at a slight angle. The joints show no apparent system. On the west the vertical section is approximately as follows, beginning at the top:

	Feet.
1. Glacial drift	12
2. Shaly rock	15
3. Shaly beds	1 to 4
4. Dark-colored red sandstone.....	6
5. Callous	1
6. Light-colored sandstone, thick beds	8 to 15
7. Callous	3 to 4
8. Dark-colored harder sandstone	4 to 6

In the glacial drift the material is mostly red shale. Nos. 4, 6, and 8 are workable horizons. At the south end of the quarry the stripping is only 10 feet thick. Very little powder is used. Stone is wedged off and split up after the top or stripping has been removed. One engine works both derricks, and the pumping is done by a small engine. The material from this quarry has been used for the construction of the Collegiate Reformed church, Fifth avenue and Forty-eighth street; the Saint Thomas Protestant Episcopal church, Fifth avenue; the Jewish synagogue; Presbyterian church, Lexington avenue; Reformed Episcopal church, Madison avenue; Trinity Church school, Church street—all in New York city; Saint Peter's Episcopal church, Albany, New York; La Fayette College buildings, Easton, Pennsylvania; Yale College buildings, New Haven, Connecticut; Princeton College buildings, Princeton, and Kirkpatrick's chapel, Rutgers college, New Brunswick, New Jersey, and many other buildings, especially in Newark.

The Newark quarries are all conveniently located for transportation. There is natural drainage, as the quarries are on a ridge or the highest ground in Newark, which is 100 feet above mean tide-level. The thickness of workable strata, the pleasing shades of color, and the fine texture and evenness of grain are circumstances very favorable to these quarries, but the value of the land for building purposes is high.

If the quarry between Fifth and Sixth avenues the strata quarried are remarkable for their thickness and solidity, and the joints are wide apart. One system of joints runs northeast and southwest, and is clean and open. The glacial-drift covering is about 30 feet thick, but varies to 10 feet in thickness in places. The quarry is nearly square, having sides about 200 feet in length, and the stone worked has a total thickness of 30 feet. At the bottom a shaly rock is found. Very large and solid blocks can be quarried here, and some of the more solid rocks show no signs of stratification.

The following are some of the principal buildings in the construction of which this stone was used: The college dormitory and the Marquand chapel, Princeton, New Jersey; Trinity chapel, Houston street; Saint Jerome's church spire, and the trimmings of buildings on the corner of Thirty-second street and Broadway, New York city.

At the corner of Bloomfield and Prospect avenues is an old quarry formerly worked very actively, but it is about to be closed, as land here is considered too valuable for quarry purposes. The quarry has a length of 700 feet and is 300 feet wide and 60 feet deep at the deepest point. The glacial-drift covering is on an average 15 feet thick. On the north side there are two workable horizons each 12 feet thick and separated by shaly beds 3 feet in thickness. The location is northeast of that of the Newark Quarry Company, and crosses Bloomfield avenue about 150 yards away.

A short distance west of this quarry, and on the same excavation, a new quarry was opened in 1880. The excavation measures 50 by 50 feet and is 40 feet deep. The beds are covered to a depth of from 5 to 8 feet by glacial drift. The ledge here opened is shaly at top, and there is first a thickness of from 10 to 15 feet of red sandstone. Beneath this there is a drab-colored sandstone 12 feet thick. Its shade of color and fineness of grain recommend it, but the extent of the supply is still unknown. The dip of the ledge is to the northwest.

The principal quarry at Orange mountain, in Essex county, produces stone for ordinary building purposes, used in Orange and vicinity. Among the buildings in which it may be seen are the Central Presbyterian church, the addition to Grace Protestant Episcopal church, South Orange Presbyterian church, and the residence of Davis Collamer, at Orange, and that of Kenyon Cox, at Millburn. The quarry is in the eastern face of Orange or Watchung mountain, and about 250 feet higher than Orange. An excellent Telford road within 250 yards of the quarry leads to Orange and Newark. There are in all 14 feet of workable beds, one of which is 6 feet in thickness. There is considerable thickness of stripping, which consists of reddish shaly beds. This stone presents a pleasing appearance when dressed, either ax-hammered or bush-hammered, and is readily dressed. Like all the stone of Essex county, it hardens on exposure. The working advances in the direction of the dip; hence there is no advantage of gravity in getting blocks from the beds. There is a fault running north and south through the quarry, but the dislocation does not appear to be great. The plane of the fault dips about 85° to the east. The rock surfaces are coated with yellowish earth, and in places the rock is crumbling, so that there is no workable or marketable stone for a distance of from 1 foot to 3 feet from the fault plane.

There is a quarry at West Orange, Essex county, which produces a rather fine grained brownstone, used for buildings and trimmings, chiefly in New York and Orange. This quarry is in the valley between the first and the

second Watchung mountain ranges and near the summit of the second range. It occupies the same relative position as the well-known Little Falls quarry. The stripping is not heavy, so that the aggregate thickness of workable beds is about 40 feet, but this does not include all, as there is said to be good stone at the bottom. The stone is heavy-bedded, and a set of regular and true joints extends through the ledge which facilitates the work of quarrying. The stone when quarried is easily dressed, and can be carved into any desired forms. It hardens by exposure. At present there is the disadvantage of having to move the stone by team a distance of from 2 to 4 miles before reaching railroad or canal. Among the most important buildings in the construction of which the stone from this quarry was used are the Presbyterian church at Caldwell, chapel of Grace Protestant Episcopal church at Orange, Reformed church at East Orange, Niles' mansion, Bloomfield, and a house at the quarry. Much of the stone was used in the construction of college buildings at Garden City, Long Island. During 1880 nearly all the material quarried, including a common rough stone, was marketed, the rough stone being used chiefly for walls at Garden City.

The gray feldspathic sandstone of the Palisade mountain is found in a crumbling condition on the east face of the Palisades and near the river, but not there suitable for building. At Englewood and Tenafly, in Bergen county, it is found so abundant in loose masses that this source has furnished stone for many elegant country houses and public structures; but no quarry in the rock *in situ* has as yet been opened.

At Paterson (in the western suburbs) a light-colored buff stone has been quarried to some extent. The pleasing shade of color and its ease in working give it a local use.

The principal quarry near Paterson is in the eastern face of First mountain. The average stripping has been 15 feet thick, largely a red shale and sandstone with trap-rock débris fallen from cliffs above. The working has reached the trap-rock wall, and now must be carried laterally or the trap-rock must be undermined. The rock face presents a vertical section, the divisions of which are approximately as follows:

	Feet.
1. Trap-rock.....	80
2. Red-shale rock.....	8
3. Red sandstone of varying thickness.....	15
4. Sandstone and shale irregularly alternating.....	10
5. Sandstone in two thick beds with shale intervening in places.....	20
6. Shale.....	1½
7. Grayish sandstone of the best quality for building purposes.....	15

The stone most used comes from Nos. 5 and 7 of this section. The quarry has advantages in location, giving a great thickness of strata above all drainage, and being situated, as it were, on the bank of the Morris canal. There are also three railroad stations within one mile. The principal markets are Paterson and Hackensack. Some is shipped to Newark and to Jersey City. The character of this material as to durability may be observed in the Passaic County jail building, and in many other buildings in Paterson and Hackensack. The principal drawback is the heavy stripping in the trap cliff; this might be thrown down and the stone utilized for roads. Professor Smock, of the New Jersey geological survey, thinks the stone under the trap-rock will probably be found more solid and in thick workable beds. (a)

In Washington valley, and at Martinsville, in Somerset county, there are quarries in the lighter-colored stones which look well in buildings. At the principal quarry at Martinsville the stripping at the north end is 21 feet thick, and consists mostly of red-shale earth at the top and red sandstone below. Some of the beds in the stripping furnish stone suitable for foundations. At the opposite end of the quarry the stripping has ranged from 10 to 30 feet. The total thickness of the courses now worked is about 20 feet, 11 feet of which is a light-colored freestone. At the bottom of the quarry a greenish shale sets in. The dip of the strata is 10° north-northeast. Most of the stones taken out are from 1 foot to 2 feet in thickness, but blocks 3 feet thick and 12 feet square may be obtained. The stone is readily sawed and dressed; gang-saws cut about 1 inch deep per hour in it. The light-colored stone is sawed into shape for caps, window-sills, lintels, water-tables, etc. The principal markets for the stone from this quarry are Boundbrook, Somerville, Plainfield, Brooklyn, and neighboring places. Among the buildings in the construction of which it was used are those in Prospect park, Brooklyn, and a hotel in Martinsville. In old buildings where this stone has been used it proves to be durable.

At New Brunswick and along the Raritan River valley the stone is too shaly and does not weather well. The quarries are not now worked.

The Delaware River quarries supply a large quantity of stone to Trenton, Lambertville, Bordentown, Burlington, Philadelphia, and Camden. This stone varies somewhat in the different quarries. It is conglomeratic in the Prallsville quarries and in some of the beds at Greensburg. The best stone is of a reddish-gray shade, and contains a little feldspar associated with the quartz. The stone is easily dressed, and is used for both ornamental and common building work. Much of the Stockton-Prallsville stone has been used in the construction of heavy bridge work on the lines of the Pennsylvania Railroad company. The stone on this side of the state appears to be a little more open and porous than that of the Little Falls and Belleville quarries, and it favors the growth of a green fungus (?) in dark and shaded outside localities.

There are four important quarries at Greensburg, and the stones from all of them are known in the market as "Trenton brownstone" or as freestone. The quarries are about four miles from Trenton, on the bank of the feeder of the Delaware and Raritan canal, and near the line of the Belvidere Delaware railroad; the Delaware and Boundbrook railroad crosses the Delaware river within a mile of the quarries. The general direction of the dip is north-northwest to an angle of about 10° . Some of the stripping consists of a friable and coarse-grained stone made up of a mixture of quartz and feldspar, with some red-shale rock in places. The workable beds are from 12 to 15 feet in total thickness. These beds are usually separated by from 3 to 4 feet of red-shale beds. The total thickness of merchantable stone is in some places 35 feet. The proximity of these quarries to both canal and railroad, their easy drainage, comparatively light stripping, and the thick beds of workable stone, are very considerable advantages. Its durability and the ease with which it is dressed create a large demand for this stone; the sale of the dirt and rotten rock of the stripping at a compensation sufficient to pay for removing it is another considerable advantage. The Trenton brownstone or freestone is most largely used in Trenton, and nearly all of the stone buildings are of this material; it is quite largely used in Philadelphia also, and a little is used in the towns along the Delaware river from Lambertville to Philadelphia. The following are some of the principal buildings in the construction of which the Trenton brownstone was used: House of Correction at Holmesburg, Pennsylvania; Catholic church, third and Reed streets; the Episcopal church, Nineteenth and Wallace streets; Presbyterian church, Twenty-first and Walnut streets; Presbyterian church, Twenty-second and Bainbridge streets; school-house, Sixth and Coates streets, all at Philadelphia, Pennsylvania; the library building at Princeton, New Jersey; Saint Mary's church at Warren and Bank streets; and the residences of Hon. A. G. Ritchie, Rev. R. S. Manning, S. Prior, and others, at Trenton, New Jersey. For the composition of these stones see *Geology of New Jersey*, 1868, pp. 515, 516.

FLAGGING STONE.

At two localities, Woodsville, Mercer county, and Milford, Hunterdon county, flagging stone is obtained. There are several distinct openings near Milford. The quarries at Milford are all within two miles of the Milford Railroad depot, and are in the dark blue fine-grained sandstone of the Triassic formation near its junction with the gneissic rocks of the Archæan age. A full description of these localities may be found in the *Geology of New Jersey*, 1868, pp. 521, 522. The quarries are at present worked only for local markets along the Delaware river from Easton to Lambertville. The beds are generally quite thin, and most of the stone splits nicely, giving a smooth surface suitable for floors or sidewalks. The maximum thickness of flag-stone produced here is 4 inches; thicker layers are used for building purposes. The dip of the beds is 20° N., 40° W. A fine dividing plane or joint traverses the stone in a direction N. 75° E.; another runs N. 15° W. Impressions of stems, fragments of coal, and some supposed foot-prints have been found in this locality. The following is an analysis of this flag-stone made for the New Jersey geological survey:

	Per cent.
Sand and silicic acid.....	79.25
Protoxide of iron.....	3.78
Alumina.....	7.49
Lime.....	1.86
Magnesia.....	Trace
Potash.....	0.50
Soda.....	0.62
Sulphuric acid.....	1.39
Carbonic acid.....	1.46
Water.....	2.76
Moisture.....	0.40
Total.....	99.51

The principal quarry at Woodville is in a dark-colored, fine-grained shale of the Triassic age. The surface layers are shale; the beds below are a fine, bluish, slate-like rock, which, however, is properly classified with the sandstones. The dip of the strata is 20° N., 4° W., very irregularly bedded in layers varying in thickness from very thin flagging to those 16 inches thick. The excavation in the quarry is 40 feet deep at the deepest point. Stripping is easy and drainage natural, but the stone has to compete with the Hudson River blue-stone at Trenton and on the railroad lines; as better prices are obtained in the immediate neighborhood than at Trenton, the local demands regulate working. The fineness of grain and smooth surface of this stone make it desirable for flagging; although a slate-like rock, the cleavage is not of such a nature as to permit it to be used as roofing material. Flag-stone or inferior quality is obtained at Princeton also. Martinsville quarry affords some stone suitable for flagging. In all of these places the stone is chiefly a fine-grained, slate-like rock, and generally of slate color. One of the quarries at Princeton produces what is called by Professor Smock a "blue, indurated, argillaceous sandstone", although, according to the classification adopted in this report, it is put with the slates. It is used for ordinary building purposes in Princeton.

Another quarry produces a grayish sandstone used to a limited extent for building purposes at various places along the Delaware and Raritan canal, and was used to some extent in the construction of the Princeton College buildings.

TRAP-ROCKS.

The trap-rocks included in the sandstones of the Triassic in New Jersey are quarried extensively, their principal use being for paving. The stone splits readily into blocks of specification sizes for street paving, and is hard, wearing well. For such use the oblong-shaped blocks are found to be quite as good as granite, and their employment is increasing in New York and in cities of the state. The quarries for paving blocks are confined mostly to the east bluff of the Palisade Mountain range, or Bergen hill, and to Goat hill, near Lambertville, in Hunterdon county. For building, the trap-rock has been used in Jersey City and in Orange, but not to any great extent, although for large structures it is well adapted and looks finely. Trap-rock is also used largely for ballasting railroad beds and for Telford roads.

REFERENCES.—*Sandstone*.—(Analysis.) See *Geology of New Jersey*, 1868, pp. 215, 218. Trap-rock: *An. Rept. N. J.*, 1873, pp. 113, 114; *ibid.*, 1879, pp. 25, 26; *ibid.*, 1881, pp. 60, 63.

The principal quarry in the Triassic trap, or diabase, is at Bergen hill, Hudson county. It is used for paving blocks chiefly in New York, Jersey City, Hoboken, and Newark. The trap-rock quarries at this place are confined to the eastern brow of the hill and to the summit of the range. They extend at intervals from Montgomery street, Jersey City, to the Bergen County line, a distance of 7 miles. These quarries are very small; they are opened on the brow of the hill where streets are to be cut through, or on knobs such as mount Pleasant, near the track of the Pennsylvania railroad, which is to be taken down to a much lower level. Others are so located as to get stone most easily and of quality suitable for use. The excavations are not sunk into the rock, but are simply extended into the ledge as it projects from the hill. There is but little stripping, cap-rock, or waste of any kind; nearly all of the rock is used. All the quarries are worked on leases, and a common practice is for a gang of three or four men to work together. The only capital is the value of tools and powder, averaging probably less than \$100 to each quarry. The specification paving blocks are cut 8 by 10 inches (or by 12) by 4 inches; the square blocks are 5 or 6 by 7 inches. The former are cut with some regard to dimensions, but the square blocks are cut with much variation, some having nearly twice the cubical contents of others. There is much variation in the stones of different localities, and some cuts much more readily than others, and with less waste. The spalls are used for Telford-road making. Black powder is employed to break off large masses, which are broken up by hand-sledges, and the blocks are split out by hammers. The blocks are carted direct from the quarries to streets to be paved in New York or Jersey City. The specification block is growing in favor, and the use of trap-rock as a paving stone is increasing very rapidly. Against the square blocks there seems to be a serious objection—that its surface grows smooth very soon and is slippery; but against the oblong blocks the objection does not exist.

The location of these quarries is above all water, with natural drainage, with no stripping to be removed, and they are often worked for the double purpose of removing the stone in the grading of streets and for paving stone. As a building stone this trap-rock has been used with good results in Saint Patrick's church in Jersey City, and in the Hudson County court-house, besides other edifices both public and private. It is also used in retaining-walls.

The late Dr. George W. Hawes said of this Triassic diabase or trap:

From a specimen of the normal rock from Jersey City the feldspar was separated and was analyzed by Dr. Howe, and proved to be complex, a circumstance not indicated by the microscopic examination. The process of separation by means of the specific gravity necessitated the presence of what may be called "middlings", which were not sufficiently dwelt upon, and which may be supposed to have modified somewhat the composition of the parts. One part was a little more siliceous than labradorite, and the other analysis gave the formula of andesite. The second feldspar may be assumed to be a little more acid than the analysis.

The complexity of the feldspathic element being demonstrated in this case, we may, if we choose, by a calculation, indicate the percentage of the feldspar in the rock, if the composition of the pyroxene is known. The pyroxene of West rock has been analyzed, and if this rock is selected as typical we obtain:

	Per cent.
Anorthite	15.52
Albite	22.16
Potash feldspar	2.32
Pyroxene	54.47
Titanic iron	2.68
Magnetite	1.76
Apatite	0.32
Total	99.23

Thus the percentage of total feldspar is shown, but it is not intended in any degree to suggest that anorthite, albite, and potash-feldspar are present in these or any proportions, but a calculation is only possible when the extreme species are considered; and, these molecular relations being known, in the words of the article "it becomes easy to see how extremely diversified the feldspathic elements may be in rocks of this nature. The molecules may arrange themselves in very diversified ways, while the rocks remain identical in composition".

This method of calculating the amount of feldspar has been very often used. West rock, according to the calculation, includes just 40 per cent. of feldspar, which contains the elements that might form three species or be combined in one. In the Jersey City rock the feldspathic molecules have combined to form labradorite and andesite. In a little dike which intersects West rock, forming a bit of its western face, and identical in composition with all the rocks of this remarkably uniform system, anorthite has formed in small amount, which does not necessitate a more basic rock, since a simple arrangement of the remaining feldspathic molecules into other species could compensate for this.

It is known that Jersey City trap consists of pyroxene, two feldspars of intermediate composition, titanite iron, magnetite, and some minutely microscopic ingredients; and the occurrence of anorthite in rocks of like composition that may be supposed to have cooled under different conditions indicates that constancy of composition as regards the species of feldspar is not to be expected.

LATER FORMATIONS.

BROWN SANDSTONE AND CONGLOMERATE.—This is the only building stone found in the southern half of the state. It is a cemented sand or gravel, and the cementing material is iron oxide. It is not confined to any particular geological horizon, but occurs from the lower beds of the Cretaceous age to the latest drift, although more common in the outcrop of the red-sand bed and the drift gravel of the southeastern part of the state. In the absence of any other stone it is useful and is largely used for foundations and cellar walls. The quarries are generally small pits or shallow openings, and the stones occur in beds of varying thickness, lying upon earthy strata or beds, and covered by sand, or sand and gravel or earthy materials. In a few instances buildings have been constructed of this stone.

REFERENCES.—*Geology of New Jersey*, 1868, pp. 516, 517, and *An. Rept.*, 1881, pp. 66, 68.

At Egg Harbor city, Atlantic county, a quarry of this stone is located on rocks of Cretaceous age. A description of this quarry and the material produced by it will illustrate what is done in southern New Jersey in these quarries of brown sandstone.

The stone from the Egg Harbor quarry is durable, as it hardens on exposure, but it is not adapted to nice work, and hence its use is limited to the construction of wine vaults at Egg Harbor city, foundations, cellar walls, and occasionally bridge abutments and a few buildings; one is a Protestant Episcopal church at Batontown, Monmouth county, built of stone from the vicinity; another is the West Jersey academy at Bridgeton, built of stone quarried near the town. Some of this material was used in the construction of the large dam at May's Landing. Among the more important of the numerous quarries in this stone are the following: near Batontown, Monmouth county; Stonehill, Atlantic township, Monmouth county; Arney's mount, Burlington county; near Wareton, Ocean county; Bridgeton, Cumberland county; Egg Harbor city, Atlantic county; May's Landing, Atlantic county.

PENNSYLVANIA.

[Compiled mainly from notes of members of the Second Geological Survey, etc.]

BUILDING-STONE RESOURCES.

The ranges of the Appalachian mountains passing in a general direction northeast and southwest through the central and eastern parts of the state are the most marked feature in the geographical structure; and, speaking very generally, the exposures of the different geological formations, especially in the mountain regions of the state, are in the form of bands, of greater or less width, having the same direction as the mountains.

The oldest rocks in the state are the Archæan, in the southeastern corner; and going west and northwest newer rocks appear in consecutive order, with the following exceptions:

There is a belt of Mesozoic red sandstone passing through the southwestern corner of the state, lying unconformably on and bounded by rocks of Archæan and Lower Silurian age. This is the latest formation found within the limits of the state. It is described very fully in Vol. II, *First Geological Survey of Pennsylvania*, by Professor Henry D. Rogers.

The next important exception is the anthracite-coal fields of eastern Pennsylvania. These are comparatively narrow belts, the exposures of which are bounded by sub-Carboniferous and Devonian rocks. In the reports of the geological survey of Pennsylvania the preservation of these isolated Carboniferous strata is ascribed to the fact that there is a marked depression of the surface in this section of the state, placing the rocks much lower than those of the same age in other mountain regions.

There are small, separate areas of the Lower Silurian limestone, sometimes called Siluro-Cambrian, by Lesley, in the second Pennsylvania survey, and called by Rogers the Auroral limestone.

Among the most important in their resources of building stone, beginning at the southeast, are the Archæan rocks before mentioned, which furnish gneisses in the neighborhood of Philadelphia and Chester county; serpentines in Chester county, and slates, for roofing purposes, in York county.

The Mesozoic or Triassic belt before mentioned furnishes a brown sandstone at various localities, which material is of the same age and bears a general resemblance to the brownstone of the Connecticut valley, and there is a belt of this age in Nova Scotia furnishing sandstone of superior quality for building purposes, but it does not bear as much resemblance to the Connecticut stone as does the material of the Triassic formation quarried in Pennsylvania.

There are dikes of trap-rock cutting this Mesozoic belt at various points. A microscopic examination shows it to be a diabase, and it furnishes a very hard and practically indestructible building material, but from its hardness it is difficult to work and is dull and somber in appearance. There are quarries in these dikes at Collins station, near Falmouth, in Lancaster county, and near York Haven, in York county. Surface boulders of the material are taken up for purposes of construction on and near Cemetery ridge, Gettysburg, Adams county. The trap at this place lies a short distance south of the present southern boundary of the Mesozoic sandstone, but there is little doubt that it is contemporary with the trap dikes which cut the Mesozoic sandstone at various places. The most

important quarries at present are at Hummelstown, and the material is also quarried at Yardleyville, Lumberton, and Newtown, Bucks county, to a slight extent near Reading, in Berks county, and at York Haven, in York county.

The Lower Silurian or Aural limestone before mentioned, which covers quite a large area in Cumberland or Lebanon valley (the Shenandoah valley of Virginia), furnishes by far the largest part of the limestone quarried in the state. The isolated bodies of this limestone in Montgomery, Chester, Lancaster, and York counties, lying southeast of the main body of the strata, furnish, in Montgomery county, the "Pennsylvania marble"; but in the other counties mentioned they furnish a limestone similar to that to be found almost everywhere in the Cumberland valley.

Strata of Hudson River age, lying immediately upon the Lower Silurian limestone, in Northampton and Lehigh counties, furnish roofing slates which are extensively quarried, the trade in which is rapidly increasing year by year.

Northwestward of the Lower Silurian limestones there is quite an extended area of Devonian strata, and on these there are ledges of Catskill sandstone in Pike county and vicinity that are much quarried for flags. The material is of the same structure and character as the North River blue-stone so extensively quarried in Ulster county, New York, for flags, and is scarcely distinguishable from it; it is marketed with the North River blue-stone and bears the same name.

The strata in this region are usually thin and evenly bedded shales and sandstones, hard, fine, and compact in texture, and particularly well adapted to paving purposes. In Wyoming county, in the vicinity of Meshoppen, there are quarries located on Devonian strata of the Chemung horizon, and the material is a very superior, fine-grained, compact, light gray or bluish sandstone, well adapted to the better class of construction, which is rapidly coming into use in New York and other eastern cities. Although the courses here are usually sufficiently thick to furnish material suitable for massive construction, much of it is thinly-bedded and is extensively quarried for sidewalk paving.

There are flag quarries also in Susquehanna and Tioga counties, and numerous other quarries are distributed over the country covered by these rocks, but the localities mentioned are the principal ones thus far where they have been quarried for purposes of construction.

There are numerous quarries of sub-Carboniferous flag-stone, probably of Chemung age, and certainly belonging to the Venango Oil group, along the high divide overlooking lake Erie, in Erie county.

There is one important quarry of umbral or mountain limestone (a division of the sub-Carboniferous in Pennsylvania), near Connellsville, Fayette county, quarried for street paving, and marketed thus far chiefly in Pittsburgh.

The Carboniferous area in the western portion of the state furnishes but little excepting coarse sandstone and conglomerates, which have been extensively used for local construction, but are usually not of such a quality as to justify their being shipped to distant points. There are, however, a few quarries producing material of such quality that they are used to some extent for building purposes in neighboring towns and cities; among these may be mentioned a quarry at Gallitzen, on the Pennsylvania railroad west of Altoona, and the quarries at Baden, Homewood, and Beaver Falls, in Beaver county. In Washington and Greene counties there are ledges of Coal-Measure sandstone sufficiently durable and of good quality for ordinary uses, though they have been as yet but little used.

ARCHÆAN ROCKS.

The southern gneissic district described in the geological reports of Pennsylvania, as ranging from the Delaware at Trenton to the Susquehanna, south of the state line, and lying south of the limestone valley of Montgomery and Chester counties, is the district in which are located nearly all the quarries of gneiss in the state; and those furnishing most of the material are in the vicinity of Philadelphia. This rock is here extensively used for foundations, walls, docks, paving blocks, curbs, and rubble work. It is for the most part a hornblende gneiss; in some of the quarries it is a muscovite gneiss, and there is a quarry at Frankfort, in the Twenty-third ward, Philadelphia, producing material which may properly be called a biotite granite.

There are quarries of hornblende gneiss at Rittenhousetown, Twenty-first ward, Germantown, Twenty-second ward, and Jenkinstown, Montgomery county. This material is gray in color, varying from light to dark and from fine to coarse in texture. It usually lies in sheets sometimes horizontal, sometimes vertical, though they are found inclined at every angle. It usually splits very regularly in the direction of the lamination, and is conveniently wrought into regular blocks for the purposes for which it is used. Some varieties of the gneiss are subject to decay from the decomposition of the feldspar, by means of which the rock is disintegrated.

Near Chester, Delaware county, the gneiss is very extensively quarried for the same purposes for which it is quarried within the limits of Philadelphia. The ingredients of which it is composed vary within certain limits, so that, according to the system of nomenclature used in this report, some of it is called a biotite gneiss, some biotite-muscovite gneiss, and some muscovite-biotite gneiss. The proximity of the quarries to the Delaware river affords ready means of transportation to Philadelphia and other cities and towns bordering on that river. The following

list includes some of the important buildings in which this stone has been used, chiefly for foundations: The Cooper hospital, Camden, New Jersey; church in Chester, Pennsylvania; Catholic church, Third and Reed streets, and Presbyterian church, Nineteenth and Green streets, Philadelphia; Saint Charles Bartholemew church, near Philadelphia; railroad-station buildings, Overbrook; fort Delaware, built largely of this rock; various light-houses along the Delaware river; and the following structures in Philadelphia: Chestnut Street bridge (partly); Market Street Bridge abutments and piers; Junction Railroad bridge; Manayunk bridge; Penrose Ferry bridge; foundations of Market Street gas-works; foundations of Girard college; Fairmount water-works; Blockley alms-house; the old Naval Asylum and the Arsenal buildings. Also Swarthmore college, Delaware county.

In many private residences in Philadelphia and vicinity the walls are built of rough blocks of this stone firmly cemented together and presenting a very pleasing appearance.

As before stated the principal quarries in the Mesozoic trap are at Collins station, Lancaster county, and some in a dike on the opposite side of the Susquehanna river near York Haven, York county. The following description of the York Haven trap will give a general idea of these dikes wherever exposed. The face of this particular quarry is about 70 feet in height, but the material extends to an unknown depth. It lies in huge natural blocks sometimes weighing hundreds of tons, and having curved outlines giving them a sort of oval shape. Smaller blocks of various shapes are wedged in between the larger ones, and sometimes regular parallel sheets are seen lying together, usually near the top of the mass. The stone is reduced to proper shape by drilling rows of holes about three inches in depth and using plug and feather. It splits well in two directions. Stone from this quarry is used only by the Northern Central railroad in the construction of bridges, culverts, etc., and its indestructible nature and the fact that it may be quarried in regular massive blocks of any desired size make it a very desirable material to be used for these purposes.

At the Kellar quarry, Collins station, the stone is more extensively quarried than at any other place in the state, and is used for curbing, steps, base courses, cemetery work, caps, sills, columns, etc. The stone is used in the foundation of the new Harrisburg post-office, the superstructure of which is of the Richmond, Virginia, and Manchester, New Hampshire, granites; and the soldiers' monument at Harrisburg is a rectangular obelisk wholly built of this material.

There is much information concerning the geographical limits, geology, and character of material of these trap dikes in Report C C C, *Second Geological Survey of Pennsylvania*.

The material of the trap boulders quarried near Gettysburg, and before referred to, is a diabase exactly similar to the stone in these dikes wherever they appear; but in this immediate vicinity there is an unusually large number of surface boulders, and they have thus far supplied all the stone quarried here, there having been no necessity to operate on the dikes in place. The boulders are particularly numerous and of large size in the vicinity of Vincent's Spur, Round Top, and Little Round Top, prominences of Cemetery ridge, along which the army of the Potomac was posted during the battle of Gettysburg. The places mentioned are all in close contiguity; and Devil's Den, where there is also a fine exposure of these trap-rocks, lies also at the base of Round Top. The boulders are also to be found at Culp's hill, the northern extremity of Cemetery ridge. The stone is obtained in regular blocks by plug and feather, in the same manner as at Collins station and York Haven, and is used to a considerable extent for steps, caps, curbs, bases, and cemetery work in general. The stone is used in the Gettysburg national cemetery as head-stones. It may be seen in use in nearly all the towns within a radius of 50 or 60 miles of Gettysburg, and is known as Gettysburg granite.

SERPENTINE AND SOAP-STONE.

Serpentine is becoming more and more popular as a building material. The Chester County stone has attracted much attention in many quarters. Quite a number of important buildings have been constructed of it in Philadelphia, Washington, and Chicago. The stone is apparently very durable, and buildings in the neighborhood of West Chester, which have been erected over one hundred years, are fresh and maintain their attractive color unchanged. The stone is easily worked, and it is claimed that it can be furnished at a smaller cost than any other stone at the quarry.

Professor Henry D. Rogers, in Vol. I, *Geological Survey of Pennsylvania*, describes a number of belts and outcrops of serpentine in the southeastern corner of Pennsylvania south of the limestone valley of Montgomery and Chester counties. The first, or the most northwesterly, serpentine and steatite range is near the Schuylkill river in the southern edge of Montgomery county, and is the most eastern zone of the magnesian rocks in southern Pennsylvania. It is a long, straight, narrow line of outcrop of steatite or serpentine crossing the Wissahickon creek and the Schuylkill river. The steatite in this belt predominates, serpentine being usually dispersed through it in lumps. The steatite, where sufficiently free from the serpentine, was formerly quarried for the lining of stoves, fire-places, and furnaces; the principal market being the city of Philadelphia. It is also sawed into slabs of various thicknesses and used for mantels, stoves, sinks, etc. The debris is sometimes ground into a flour and used for foundry facings, lubricating purposes, roofing material, in paint manufacture, and for various other purposes.

Toward the end of the last century, before the introduction of the Montgomery County marble, this easily-quarried material was used for street-door steps in Philadelphia, but its unequal hardness, owing to the dispersion

of imperfectly-crystallized lumps of serpentine, caused it to wear unevenly and to soon present a rough appearance; and Professor Rogers notices the fact that in some old and much-worn door-sills of this rock the knots of the serpentine mineral project above the steatite like hob-nails in a plank. The fifth serpentine tract, or that of the West Chester barrens, is the one which has been quarried most for building purposes. The rock here is of a grayish-green color, massive, medium fine and uniform in texture, and has been extensively used for buildings, principally as ashlar in walls. The principal markets are Philadelphia, Baltimore, New York, and Washington, and it has been shipped as far west as Chicago.

Among the principal constructions of this stone are the Girls' Normal School building, Seventeenth and Spring Garden streets, Academy of Natural Sciences, Philadelphia; Pennsylvania University buildings, West Philadelphia; the court-house, Wilmington, Delaware, and 20 large churches, a number of school buildings, and several hundred private residences in Philadelphia, and more particularly in West Philadelphia. A portion of the material is sawed at the quarry. Several old farm-houses in the neighborhood built of this stone more than a century ago are reported, two having been erected in 1730; and the color of the stone is as perfect as when first quarried. A number of columns 6 feet long and 12 inches in diameter were furnished from this quarry for the university of Pennsylvania. This is about the longest that can be obtained, but it is not difficult to find good sound pieces 4 feet long and 6 or 8 inches thick. The broken and jointed character of the rock renders it impossible to obtain large blocks, hence its chief use thus far has been as ashlar in the walls of buildings. This stone can be readily carved, but cannot be sawed into very thin slabs. Although it has only been introduced to the public in the past ten years, it has been very extensively used by architects and builders, especially in Philadelphia. The quality of the stone both as to color and texture is more uniform in every respect than it was when the quarries were first worked, and the supply appears to be practically inexhaustible.

Near Rising Sun, Maryland, in the southern edge of Chester county, Pennsylvania, there is a serpentine tract upon which is located a quarry, formerly extensively worked, but which was idle during 1880. There are also one or two other quarries on this tract in the same locality; and there is a quarry of serpentine near Media, Delaware county, which, however, was not operated during 1880. Some of the stone for the building of the Pennsylvania university, West Philadelphia, was obtained at the Media quarry, and some at the quarries near Rising Sun, Maryland.

LIMESTONE.

LOWER SILURIAN.—At the Bushkill quarries, Easton, Northampton county, the lowermost portion of the great Lower Silurian limestone of Pennsylvania, known as the Calciferous, is quarried for ordinary building purposes, and has quite an extensive local use for base courses and curbs, and is also burned for lime. An analysis of the stone shows it to be highly magnesian; in fact it may properly be called a dolomite. Graphite and protoxide of iron are found in specimens of the stone. The limestone in and around Easton is in comparatively even beds, and good stone of proper shape for building purposes can readily be obtained, though the stratum inclines sometimes at high angles. The base of the court-house and many other buildings in Easton are of this limestone, chiefly from the Bushkill quarries.

MONTGOMERY COUNTY MARBLE.—The Montgomery County marble, so extensively used in Philadelphia, is quarried from an isolated belt of the great Magnesian or Auroral limestone of Lower Silurian age. Professor H. D. Rogers, in the *Report of the First Geological Survey of Pennsylvania*, describes the geographical limits and geology of this limestone belt substantially as follows: It is the bed of a long, narrow valley in Chester and Montgomery counties; the ridges bounding the valley consist of the primal slates and primal white sandstone. The whole is a narrow, synclinal basin, with strata closely folded together, those of both sides of the trough dipping with much regularity to the south-southeast at an angle ranging between 60° and 70°. All the strata here are greatly altered by diffused igneous action. The belt of limestone itself, which forms the great valley, extends through the western half of Montgomery county, southwestward through Chester county, and Sadsbury and Bart townships, in Lancaster county. The general geological structure of this populous and rich limestone belt, is extremely simple. Measured from one extremity to the other, the limestone, coincident very nearly with the bed of the valley, has a total length of about 58 miles; its eastern end being just north of Abington, in Montgomery county, and its western end is at the source of Big Beaver creek, in Lancaster county. In form it resembles very much a long, slender fish. The general structure of this first main belt of the Auroral limestone is that of a long and slender basin or a synclinal trough, the southern side of which is much steeper than the northern. The strata of the southern side of the valley dip perpendicularly, often a little overturned into a steep south dip, but sometimes incline steeply in the normal direction or northward. It is only toward the western extremity, where the whole trough grows shallow as it rises up and thins away, that the north dip ceases to be steep. The strata of the north side of the valley, or from the synclinal axis northward, dip at an average inclination of about 45° southward, or more strictly, south 20° east; this inclination, however, is not absolutely constant. Throughout this limestone basin the southern steeply-upturned outcrop exhibits a far higher degree of metamorphism by heat than the northern, and this alteration appears greater where the strata approach most nearly a vertical position, and is greater still where they are inverted; that is to say, between Wissahickon and Brandywine creeks. It is chiefly within these limits that the elsewhere bluish and yellowish limestone is in a condition of crystalline and granular marble, white shaded

or mottled from the dispersing and segregating action of a high temperature upon its changeable ingredients. All the marble quarries hitherto opened are included in this steeply-upturned or overturned outcrop, the best of this lying within half a mile of the southern edge of the formation, or of some sharp, inverted anticlinal like that of the Conoquenessing ridge. Throughout the northern half of the basin, especially where the limestone observes its usually very regular southward dip of seldom more than 45° , the rock is in the condition of a subcrystalline and earthy or purely sedimentary magnesian limestone, and its bedding is for the most part very uniform and rather thick. Its color is a pale greenish-blue, except in neighborhoods like that on the Schuylkill, below Norristown, where a partial metamorphosis has approached the northern border, and it is then very frequently a pale straw color and a pale bluish-white; but the slate in which the very same beds exist, where they rise perpendicularly or with inversion to their southern outcrop, after passing the synclinal turn in the center of the basin, is very different from all this, and in striking contrast with the faintly crystalline and earthy limestone which is here a distinctly-crystallized and often granular marble. Its color is changed to a brilliant white or to a mottling of purely white and dark blue from the presence of segregated or half-developed graphite, and the dispersed ferruginous matter is here in a state of minute, solitary crystals of sulphuret of iron disseminated through the body of the stone. Viewed edgewise a fresh exposure of the most altered limestone, such as is visible on the Schuylkill river, near Conshohocken, has the aspect of a blue and mottled marble streaked with films of talc and shivered by innumerable cleavage joints; but viewed facewise the layers and fragments have an aspect of a talcose or micaceous slate, so copious is the covering of talc and mica upon their surface.

The belt of marble in Montgomery county is about three-quarters of a mile wide, and it is in this county that the principal quarries on this belt are now operated. Marble Hall, in this county, is the easternmost point at which good marble is quarried, and the best of the material lies between this point and the Schuylkill river nearly to the Chester County line.

A mile from Spring Mill station on the Germantown and Norristown railroad the marble is quarried for buildings, cemetery work, and furnace flux, and shipped to Philadelphia, Lancaster, and other places in Pennsylvania, and to Washington, District of Columbia. The stone here varies in texture from coarse to fine, is semi-crystalline, light blue in color, with signs of irregular stratification, unevenly bedded, and in medium to thick layers. Blocks of 500 cubic feet might be moved in this quarry. Steam-drills are used in quarrying, and powder, and to some extent dynamite, in blasting. The production here during 1880 is said to have been less than the average.

Near Bridgeport, Montgomery county, the marble is quarried for ordinary building purposes, and shipped chiefly to Philadelphia and throughout Pennsylvania. It is here of a light blue, fine, semi-crystalline texture, with signs of irregular stratification, evenly bedded, and in medium to thick courses. It was used in the construction of the following buildings in Philadelphia: Girard college, United States custom-house, Merchants' exchange, and the passenger depot of the Pennsylvania railroad, at Broad and Filbert streets.

Near King of Prussia station, on the Chester Valley railroad, in Montgomery county, marble is quarried for ordinary building purposes, and shipped to Philadelphia, Baltimore, and throughout Pennsylvania. It is blue, has a fine, semi-crystalline texture, signs of irregular stratification, is rather unevenly bedded, and in thick courses. Plate V represents the polished surface of a specimen of this marble. It was used in the construction of Girard college, the new city building at Broad and Market streets, the old post-office and numerous churches in Philadelphia, and the court-house at Norristown.

At Henderson station, Montgomery county, similar marble is quarried for ordinary building purposes, and shipped to the cities of Philadelphia, Baltimore, and Washington. This marble was used in the construction of the Law Library building in Philadelphia.

At East and West Conshohocken, in Montgomery county, on opposite sides of the Schuylkill river, the ledge is quarried, the product being commonly known as limestone. It is gray, with a rather coarse, semi-crystalline texture, irregularly stratified, and comparatively even bedded in layers of varying thickness up to 2 feet; it is but little jointed, and its difference in texture and structure from the material in the marble quarries of this district is apparently due to less disturbance of the strata. The principal use of the stone at present is for foundations and bridge abutments. The stone-work of the Philadelphia and Reading Railroad bridge at the falls of the Schuylkill and that of the Girard Avenue and the Callowhill bridges, Philadelphia, is of this material. The following are some of the buildings the foundations of which were built of stone from the West Conshohocken quarries: The new city buildings, Broad and Market streets; Masonic temple, Broad and Filbert streets; Main Exhibition building, Memorial hall, Machinery hall, and Horticultural hall, in Fairmount park; Philadelphia Saving Fund building; Provident Life and Trust Company building, and the Union Insurance Company building; new grain elevator of the Philadelphia and Reading Railroad Company; South Street bridge; E. H. Fidler & Co.'s new buildings at Bridesburg; bridges on line of Philadelphia and Reading railroad, and on the connecting link of the Boundbrook line to New York.

Beside the limestone or marble of the Lower Silurian or Siluro-Cambrian belt of Montgomery county, there are quarries at various other points in Pennsylvania on this formation where the stone is quarried for ordinary building purposes, chiefly to supply local demands. There are quarries of this kind at Easton, as before mentioned, at Tuckerton and Reading, in Berks county, and in Lebanon county; near Harrisburg, Dauphin county; Leaman Place, Lancaster county; York, York county; and at Bridgeport, Shiremanstown, and Carlisle, Cumberland county.

There are also numerous other points where the material is quarried principally for lime, and where but little of the product is used for building purposes. At Tuckerton the stone is gray in color, massive, and the courses are even and thick. The stone is a calcareous dolomite. It lies in courses varying from about a foot at the top to 2 feet or more in thickness at the bottom of the quarry, and the total depth of stone quarried is about 50 feet, the inconvenience of drainage being the cause for not going deeper. The joints are from 3 to 20 feet apart. This quarry is operated by the Philadelphia and Reading railroad, chiefly to obtain stone for bridge construction and other railroad work. The inclination of the strata at this quarry is about 4° or 5° , and, contrary to the condition of the rock at other places near Reading, it is not much broken by joints, and hence is in a more favorable condition to be used for building purposes. Portions of the ledge of limestone not far distant from the Tuckerton quarry are upturned at a high angle, very much jointed and broken, and are quarried extensively for lime burning and furnace flux. The material the point where the Tuckerton quarry is located is a limestone, but is not of sufficient purity to be well adapted either for furnace flux or for lime burning, but the regularity of the strata and the substantial and durable character of the stone recommend it for building purposes. (a)

At Reading, a few miles south of the Tuckerton quarry, this limestone is worked only to a depth to which natural drainage is obtained—10 or 15 feet. Stone similar in character to that quarried extends downward to an unknown depth. In some sections of the quarries the ledge is a solid mass, and in others the division of the layers varies from 4 inches to 1 foot in thickness. The inclination of the strata is 45° . The stone is of a bluish color, with indistinct signs of stratification, fine in texture, and a qualitative analysis shows that it contains graphite, protoxide of iron, much lime, and considerable magnesia. It is scientifically a calcareous dolomite. This stone is well adapted to the purposes for which it is used in Reading and vicinity, such as cellar walls, foundations, curbstones, and for macadamizing streets and roads.

The Annville (Lebanon county) quarries of this formation produce limestone which is used for building, and for lime and furnace flux; the building stone and furnace flux are used chiefly at Lebanon, and considerable lime is sent to Wilmington, Delaware. The stone here is a blue-black color, irregularly stratified, fine and semi-crystalline in texture. The stone at this point contains less magnesia than that at most places in Pennsylvania where limestone of the same age is exposed. The magnesia is nearly always a prominent feature in the rock of this age in Pennsylvania, and the *Second Geological Survey* entitles it the magnesian limestone formation.

Four and a half miles southeast of Harrisburg, on the east side of the Susquehanna river, there is a quarry of this rock, producing material for building purposes, for lime, and for furnace flux. The stone here is a dark gray in color, fine, compact texture, is irregularly stratified, lies in even courses varying in thickness from a few inches to 2 feet or more, and is a magnesian limestone.

At Leaman Place station, Lancaster county, this limestone is quarried for building purposes, and is used chiefly in Philadelphia, Lancaster, Harrisburg, and on the line of the Pennsylvania railroad.

The abutments of the Conestoga bridge at Lancaster and those of the State Street bridge at Harrisburg are built of this stone. It is here dark gray in color, indistinctly stratified, and fine in texture; is a calcareous dolomite, containing graphite, some protoxide of iron, and sulphides of copper and iron. The courses are even and from 3 inches to 3 feet in thickness.

At Lancaster the stone is quarried for local use, chiefly for cellar walls and foundations. It is here blue-black in color, fine in texture, and with signs of indistinct stratification; contains a high percentage of magnesia, and is a dolomite. It contains graphite, protoxide of iron, little lime, and much magnesia. It lies in even beds, from a few inches to 2 or 3 feet in thickness, and the joints are usually from 3 to 20 or 30 feet apart. The walls of the Lancaster County prison are built of this stone. The height of the face of the quarries is about 20 feet. The strata are tilted up at an angle of about 45° , and a material of quality similar to that quarried might be obtained to an unknown depth, as is true at other quarries of the vicinity. The quarrymen find it convenient to go no deeper than the point at which natural drainage may be obtained. The rock in these quarries is not of a character to answer well for furnace flux, though the same ledge is quarried for that purpose a short distance away.

It may be observed here that throughout eastern Pennsylvania, where this Lower Silurian limestone outcrops in places where the rock was found in even, massive, thick, and little-jointed courses so as to be readily obtained in proper shape for building purposes, the material seems to contain too great a proportion of ingredients other than lime to answer well for furnace flux or lime burning; and, on the other hand, where the strata are much tilted and broken by joints so as not to be susceptible of being readily wrought into shape for building purposes, its composition is such as to make it well adapted to use for furnace flux and lime. In the Lancaster quarries, although the layers have an even surface, the stone breaks with an irregular fracture and is rather difficult to shape for other than the ruder purposes for which it is now used. Several old one-story houses constructed of this material are still standing in Lancaster, some of which were built a century ago. The only way in which the weather seems to affect this stone is to fade it to a lighter color, and this is due probably to the evaporation of the water, which process also has the effect of hardening it. This stone underlies a large area of Lancaster county and is extensively used by farmers, their barns and residences being often constructed of it. (b)

a Report M M, p. 304, *Second Geological Survey of Pennsylvania*.

b For analysis see Report M M, p. 304, *Second Geological Survey of Pennsylvania: Siluro-Cambrian Limestone*.

Near York, York county, the Lower Silurian limestone is quarried for the ruder building purposes, such as cellar walls, foundations, and bridge abutments, and to some extent for paving blocks. Nearly all the streets of York are macadamized with this stone, it being about the only material used for the purpose in the town and vicinity. There are, however, two varieties here, one used for building purposes and the other for burning and as a fertilizer. The variety which is used for building purposes is blue-black in color, fine, compact, and uniform in texture, with no signs of stratification, and contains a high enough percentage of magnesia to be called a calcareous dolomite. It contains graphite, which is doubtless a principal part of the coloring matter, little iron, much lime, and little magnesia. The courses are even, from 15 inches to 2½ feet in thickness, and almost horizontal, there being but little dip. The material is quarried with comparative ease in regular blocks for building purposes, and is used almost exclusively for cellar walls, foundations, bridge abutments, etc., the local demand being greater at present than the production.

The height of the face of the quarry is 20 feet, the material being quarried only to the depth at which the natural drainage is obtained. There is no exposure showing the actual thickness of the ledge. The stone which is burned for a fertilizer is white in color, fine and crystalline in texture, containing less magnesia than the variety used for building purposes; it also differs from it in the absence of graphite or other coloring matter, and contains a greater proportion of the carbonate of lime. The courses are uneven and irregular, being much jointed, and the natural blocks vary much in size and shape. The height of the face of the quarry is about 15 feet. It is noticeable that the dip of the strata in these quarries is from 15° to 20°, which constitutes another marked point of difference between the white and the blue-black limestone quarried near York. In some places there are divisions into layers varying from 1 foot to 6 feet in thickness, but often the ledge is simply a broken and much-jointed mass. There is always more or less metamorphism in portions of the ledge producing the white limestone, the material in some places being a kind of marble of a white and bluish mottled color. The rock when burned makes a superior quality of white lime, and would be a durable building stone, but rather too expensive, owing to its hardness and the difficulty of obtaining rectangular blocks. It has no regular cleavage and cannot be split into prismatic blocks. There has been apparently enough metamorphic action to partially destroy the stratification, but not enough to entirely convert the material into a crystalline marble. Nearly every farmer in the vicinity of York has an opening in his limestone and uses it for building purposes and for fertilizing fields. The stripping in the vicinity of York is usually a red clay of the Mesozoic or New Red Sandstone formation. (a)

At Bridgeport, on the opposite side of the Susquehanna at Harrisburg, this limestone is extensively quarried for foundations, furnace flux, railroad ballast, and fertilizers. It is here dark drab in color, fine, hard, compact, and in texture rather brittle; it is a dolomite containing graphite and some protoxide of iron. Analyses of specimens from 115 layers of the rock in these quarries are given in Report M M of the *Second Geological Survey of Pennsylvania*, which seem to show that alternate strata of limestone and dolomite make up the mass; that the dolomite layers carry the most insoluble materials, and that as a rule each layer is nearly homogeneous. Magnesia is present in greater or less quantities in all the layers. It is even and rather distinctly stratified; the bedding is moderately uneven, and varies from a few inches to 10 feet in thickness; the joints are from 6 to 20 or 30 feet apart; the strata dip at an angle of 30° or 35°, and the depth of the face of the quarries at present opened varies from 15 to 40 feet, the variation being due to prominences and depressions in the outcrop of the ledge. The railroad track running into the quarry is on the level at which the material is quarried. The bed of the Susquehanna river at Harrisburg is of this material. The upturned edges of the strata over which the waters pass may be seen from the bridges in the vicinity, as the river is shallow and the water quite clear. The limestone here is of such composition and character as not to be very soluble in water, so that it does not wear away rapidly under the action of the river, although the current is quite rapid. The abutments of the bridges are mainly constructed of this limestone. It is found most convenient not to quarry the material in these quarries below the level of the railroad track, on account of the great expense and difficulty which would be incurred in loading the cars, though the material below this level is deemed quite as good for all the purposes for which the stone is used. Several houses in Harrisburg are of this stone, notably the residences of Hon. Simon Cameron and Senator J. D. Cameron. Several miles to the westward of the Bridgeport quarries, at Shiremanstown, this limestone is quarried for building purposes and as a fertilizer. It is here blue-black in color, fine, compact, even, and distinctly stratified; the proportion of carbonate of magnesia varies so much that some of the material may be called a calcareous dolomite and some a limestone, strictly speaking. The specimen of dolomite analyzed for this report contained some graphite, some iron, a high percentage of lime, and considerable magnesia; while in another specimen from the same quarry the graphite and iron were wanting, and there was still a greater proportion of lime and less magnesia. The stone is evenly bedded, and the courses vary in thickness from a few inches to 2½ feet. The bed of these quarries is worked only to the depth to which natural drainage is obtained. The dip is about 30°, and stone of a similar quality to that quarried can be obtained to an unknown depth.

In the discussion by Professor Lesley on the analyses of specimens from 115 layers of the rock in these quarries (Bridgeport), which were referred to above, he states that alternate strata of limestone and dolomite

a See Report of *First Geological Survey of Pennsylvania*, Vol. II, p. 667, for some description of the Mesozoic rocks in Pennsylvania.

make up the mass; adding, however, that none of the layers contain a sufficiently high percentage of the carbonate of magnesia to form a true lithological dolomite. The dolomite layers are found to carry the most silicates and other insoluble materials, and as a rule each layer is nearly homogeneous. Magnesia is present in greater or less quantity in all the layers. These 115 layers belong to the lower middle part of the great Magnesian formation, and the chemical analyses show them to belong to two well-marked lithological species, one a limestone carrying 2 or 3 per cent. of magnesia carbonates and 1 or 2 per cent. of insoluble material; the other a dolomitic limestone charged with from 25 to 35 per cent. of magnesia carbonate and an average of over 7 per cent. of insoluble matter, rising in some cases to 10 and 15 per cent., or even more. The largest percentage of the insoluble silicate of alumina is almost invariably found in the higher magnesian layers. From these conclusions of Professor Lesley, and from the conduct of the limestone in the bed of the river and in old buildings constructed of it, this stone is entitled to rank very high as to durability; a comparatively high percentage of insoluble matter may have something to do with enabling it to resist water-wear and other weather exposure. As a matter of course, a soluble or otherwise easily-destructible cementing matter will disintegrate a rock, even though its chief constituents be indestructible fragments so cemented together. The specific gravity of the specimens analyzed range from 2.68 to 2.85.

In Cumberland county about one farmer out of every ten quarries this stone in a small way for local building purposes, and for plaster, fertilizers, etc. The same may be said of Franklin county, and in fact of the whole region of Pennsylvania where the formation outcrops. It would be difficult to give an intelligent estimate of the amount of the material which is quarried in this way outside of the more important quarries, though the figures, if arrived at, would be very considerable.

Progressing still farther down the Cumberland valley, we find that at Carlisle stone is quarried for caps, sills, and bases, and all ordinary building purposes; also for plaster and for fertilizers. The stone is here blue-black in color, fine in texture, and indistinctly stratified; it is evenly bedded, lying in layers from a few inches to several feet in thickness, and in some places very much and at others but little jointed. It is here a calcareous dolomite containing a little iron. In the vicinity of Carlisle much of the rock is gathered from the surface of the fields, where it is an obstruction to farming operations, and nearly all that is needed for local use is obtained from the surface blocks. Dickinson College building, which has stood for nearly a century, and several churches and private residences in Carlisle and vicinity are built of this stone; and the only way in which it seems to have been affected by the weather is that in the older buildings it has faded to a lighter color.

At Chambersburg, Franklin county, in the Cumberland valley, this stone is very similar in every way to that quarried near Carlisle; it is blue-black in color, fine and compact in texture, and the stratification is indistinct and sometimes not observable. The specimen analyzed for this report proved to be calcareous dolomite containing some graphite. The ledge at these quarries is generally worked to the depth of about 20 feet, which is as deep as it can be worked without resorting to artificial drainage. The stone is evenly bedded, the courses being from 2 to 4 feet in thickness usually, and are readily taken out by plug and feather in convenient shape for building purposes. Many farm-houses and barns in the surrounding country are built of this stone; some of them have been standing for a century, and show no evidence of being affected by the elements excepting to fade to a lighter color. Numerous small quarries in this ledge are being operated throughout Franklin county to obtain material for plaster and for fertilizers, and the amount thus quarried each year is very considerable. It is also extensively quarried, throughout the regions of Pennsylvania where it is exposed, for macadamizing streets of the cities and towns and the roadways through the country; it is admirably adapted to this purpose. Another characteristic of this stone, which has been before mentioned in connection with the quarries at particular localities, is its great durability and resistance to atmospheric conditions, with the one exception of its fading to a light color. In Chambersburg old buildings constructed of this stone are sometimes painted so as to imitate very nearly the original color, which is a dark blue or blue-black.

Near Columbia, Lancaster county, the Lower Silurian limestone is quarried extensively at the Kauffman quarry, chiefly for railroad ballast and lime-burning. It is gray in color, massive, fine, and semi-crystalline in texture; it is a calcareous dolomite, containing a little protoxide of iron; and, although having considerable magnesia in its composition, it is very extensively used for furnace flux. The total height of the face of the quarry is 85 feet, and the courses are from 2 to 10 feet in thickness. The strata are inclined at various angles, there being considerable irregularity. There are two different ledges of the limestone in this quarry, disposed non-conformably to each other, though the character of the materials is about the same. The material is not so brittle as the limestone of the Trenton age quarried for ballast at Orbisonia and Morell, in Huntingdon county, and therefore requires more labor in breaking up. There is a marked difference between the stone in the Kauffman quarry and that quarried immediately across the Susquehanna at Wrightsville, in York county. The latter is white and otherwise apparently much altered by metamorphic action, and differs from the Montgomery County marbles in being less crystalline.

At Wrightsville, in the quarry of Kerr, Weitzel & Co., the limestone is of a white and light gray color and fine, compact texture; it is a calcareous dolomite, the proportion of magnesia being considerable.

The following is an analysis of samples of four different varieties of this limestone, made by the state chemist of Maryland in Baltimore, in 1857, with a view to introducing it extensively as a fertilizer in the country bordering the Susquehanna river and upper Chesapeake bay, to which place there is ready access by canal:

	1.	2.	3.	4.
Total	100.0	100.0	100.0	100.0
Carbonate of lime.....	97.1	80.8	95.4	85.0
Magnesia	2.6	14.7	3.1	4.5
Sand, iron, and carbon.....	0.3	4.5	1.5	10.5

The limestone from quarry No. 1 is of uncommon purity, and its lime is especially adapted to application on white-oak soils. The limestone from quarry No. 2 is a weak magnesian limestone; its lime is well adapted to application on soils which are moderately deficient in both lime and magnesia. These are in particular the volcanic soils of some counties in Maryland. The stratum in this quarry is 70 feet in thickness, and is tilted up to an angle of about 45°; and, though the inclination is different at different places, there is no considerable irregularity. The material at the point where quarried has been so much changed, apparently by metamorphic action, that it has very much the appearance of what are commonly called marbles, excepting that crystallization is not so apparent. The color is sometimes white, sometimes bluish. There is no regular division into layers, the stone being simply a much-jointed mass; and it would not be practicable to obtain large, regular blocks for building purposes. The railroad depot at Columbia is built of small, irregular blocks of this material, firmly cemented together in the style commonly known as rock-faced work. It presents a very pleasing appearance, and stone for this style of construction can be obtained in inexhaustible quantities here. The stone which is now quarried is the No. 1 given in the analysis, and is chiefly burned for a fertilizer and for building lime on the eastern and western shores of Maryland, to which, as before mentioned, there is ready access from the quarry by water, although some of it is now shipped by rail.

A specimen of the Lower Silurian limestone forwarded by E. V. D'Inwilliers, of the Second geological survey of Pennsylvania, from near Yellow House, in Berks county, is a bluish-gray, fine, compact, indistinctly-stratified magnesian limestone containing a little iron.

The great Magnesian limestone formation which extends across Pennsylvania from the Delaware river to the Maryland state line, along the north foot of the South mountains, sinks northward and rises again to the surface in the valleys and coves among the mountains of middle Pennsylvania, viz, in McConnellsburg cove, Kishicoquillis valley, Morrison's cove, Nittany valley, Spruce Creek valley, etc.

A specimen from Spruce creek, Huntingdon county, is a blue-black, fine magnesian limestone, compact in texture, and breaks with a conchoidal fracture. It contains graphite.

Some description of the limestone in this region may be found in Vol. I, p. 500, of the *First Geological Survey of Pennsylvania*. This great limestone formation in Pennsylvania was called by Rogers the "Auroral" limestone, and it is termed by the *Second Geological Survey of Pennsylvania* the Siluro-Cambrian, and quite as often the magnesian limestone, from the universal presence of magnesia in greater or less quantities. The same authority also has local names for it in different parts of the state, as the York limestone, in York county; the Lancaster limestone, in Lancaster county, and the valley limestone in Chester county. For analysis of the Siluro-Cambrian limestone see Report M M, p. 304, *Second Geological Survey of Pennsylvania*.

DEVONIAN.—The only Devonian limestone quarried extensively in Pennsylvania is the Corniferous, of which there are massive beds exposed in the mountain regions in the central part of the state, and which are chiefly used for furnace flux and railroad and turnpike ballast.

Among the principal quarries on this formation are those of the Warrior ridge, at Huntingdon, where the stone is quarried for ballast by the Pennsylvania railroad. It is here a dark drab, fine, compact, and brittle material, non-fossiliferous, and contains graphite, some iron, and little magnesia. According to the system of nomenclature observed in this report it is a true limestone. The total thickness of the ledge is about 100 feet, disposed in layers varying from 8 inches to 3 feet. There are two layers of shale, each about 4 feet in thickness, one about 25 feet from the ledge, the other 5 feet lower, with limestone between. Numerous seams of calcite run through the stone. It is used only as ballast at present. It is said to furnish but a poor, mean lime when burned, and is not suitable for furnace flux.

For a description of this ledge of Corniferous limestone in the Juniata valley see Report F, *Second Geological Survey of Pennsylvania*. It contains few or no fossils, and in this respect differs radically from the highly fossiliferous Corniferous limestones of Ohio and other parts of the west.

Farther to the south, along the Warrior ridge at Cove station, in Huntingdon county, on the Broad Top railroad, the Shirley quarry is extensively worked for furnace flux, which at present is chiefly used by the Kemble Coal and Iron Company at Riddlesburg, Pennsylvania, to which place it is transported by rail. The ledge at this place is at least 200 feet in thickness, and possibly much thicker; it dips at an angle of 60°, giving the strata a

very fine position for quarry operations. One particular division of the strata deserves special notice; it is about 15 feet in thickness, divided into layers from 2 to 4 feet in thickness; is uniform in character throughout, and, according to an analysis made for the Cambria Iron Company of Cambria county, contains 98.55 per cent. carbonate of lime. It is drab in color, massive, and coarsely crystalline in texture, containing a very little iron and magnesia, and is susceptible of a good polish. It is locally known as the "fossil" limestone as distinguished from the rest of the ledge, which is non-fossiliferous. The fossils are chiefly three or four different species of brachiopods, found on the surfaces of the layers, but not within the stone, as when fractured it shows a uniform, highly-crystalline texture, as is also true at other quarries of this ledge.

The non-fossiliferous part of the ledge, according to the analysis for the Cambria Iron Works, contains 94 per cent. of carbonate of lime; is very hard, compact, and brittle, breaking with conchoidal fracture, and would not in its natural condition be well adapted for purposes of construction, excepting for ballast on railroads and turnpikes. Only that portion of this ledge, 65 feet in thickness, which extends above the level of the stream is quarried. The rapid dip of the strata carries it beneath the surface an unknown distance.

Still farther south on the Warrior ridge, at Hyndman, at the junction of the Broad Top and Baltimore and Ohio railroads, this Corniferous ledge is quarried for furnace flux for use in Pittsburgh, to which place it is transported by rail. The stone is here a dark drab, massive, magnesian limestone, containing a little protoxide of iron and magnesia. It is fine, hard, and brittle in texture, and breaks with a conchoidal fracture. The face of the quarry is 200 feet in depth, and the strata are tilted to a vertical position.

Although the strata in all the mountain regions of Pennsylvania are usually tilted at a variety of angles, it is unusual to find strata of limestone perfectly perpendicular. The layers vary in thickness from 1 foot to 2 feet in that portion of the ledge quarried. A width of about 50 feet of the strata is quarried at present, the quarry progressing into the hill, and the uptilted layers of limestone on each side forming perpendicular walls.

A considerable part of the whole ledge is made up of layers of shaly, thinly-bedded limestone. Seams of calcite are frequent. It exists in inexhaustible quantities here, and the amount quarried for furnace flux, lime-burning, and fertilizers is increasing rapidly, as new quarries on the ledge are being started.

Warrior ridge, upon which the Corniferous quarries at Huntingdon, Cove station, and Hyndman are located, is an outcrop of the Oriskany sandstone formation, which crosses the Juniata river a little above Huntingdon, and ranges northeast and southwest for many miles parallel to and facing Tussey mountain, from which it is separated by the valley of the Lower Helderburg limestone and Clinton red shale (fossil iron ore). Its crest and escarpments are cut into remarkable "pulpit rocks". The dip is usually gentle to the southeast, but there are local anticlinal rolls, with very steep or vertical northwest dips. The return of the outcrop east, south, and southwest, around the head of Standing Stone valley, brings the Oriskany and the limestones above and below it back to the Juniata at the glass-sand quarries below Huntingdon, in Jack's narrows.

SUB-CARBONIFEROUS.—The only extensive limestone quarry producing stone for purposes of construction on other than Lower Silurian rocks in Pennsylvania is on the umbral or mountain limestone, a division of the sub-Carboniferous in Pennsylvania.

This quarry is located 3 miles southeast of Connellsville, on the Baltimore and Ohio railroad, in a gap made by the Youghiogheny river in the Chestnut Ridge mountains, through which the railroad passes. The ledge on which this quarry is situated is one of the strata forming the anticlinal axis of Chestnut ridge. There is considerable dip of the strata to the northwest away from the crest of the mountain, the general direction of which is north-northeast and south-southwest. The joints in this quarry are about 15 feet apart, the ledge not being so much broken as is the case with nearly all the mountain ridges of Pennsylvania. The total thickness quarried is about 80 feet, with the bottom not reached, and the material is disposed in courses from 10 to 14 feet in thickness. Professor Stevenson, in Report K K of the *Second Geological Survey of Pennsylvania*, describes it as very compact, blue, breaking with a conchoidal fracture, and in general appearance bearing a close resemblance to quartzite. The analyses of specimens made for this report show it to be properly a limestone, containing some silica, protoxide of iron, considerable lime, and very little magnesia. Professor Stevenson describes the stone as essentially a sandstone, with cementing material of calcium carbonate, but analysis shows that it contains a sufficient proportion of carbonate of lime to be properly a limestone. It is a bluish-drab in color, fine and subcrystalline in texture, and evenly bedded.

In Pittsburgh, where there is much heavy traffic over the streets, it has given good satisfaction as a paving material; it is very hard and compact, resisting wear exceedingly well, and it is readily shaped with the hammer into rectangular blocks of a proper size for paving.

This ledge has been thought to correspond with the Maxwell limestone of southern and eastern Ohio; in Pennsylvania it is variously called the siliceous, umbral, or mountain limestone, and lies on the Pocono or Vespertine sandstone, at or near the horizon of the Waverly series of Ohio, the formation producing the fine, compact sandstone so much quarried at Amherst, Berea, Brownhelm, Waverly, and other points on the sub-Carboniferous outcrops extending through the central part of Ohio from its northern to its southern limits.

During the census year 52,000 paving blocks from this quarry were used in Pittsburgh.

CARBONIFEROUS.—The Carboniferous limestones of Pennsylvania are but little used for purposes of construction. At Van Port, Beaver county, on the Ohio river, there are quarries on the ferriferous limestone, (a) and the material is used chiefly for lime and furnace flux, though it has been employed to a slight extent for walls and foundations. The stone is a massive magnesian limestone, fine and fossiliferous in texture, containing a little protoxide of iron. The total thickness of the ledge is about 11 feet, divided into three principal layers, of which the upper is 4 feet in thickness, the middle 3 feet, and the lower 4 feet. Thin shaly layers usually cover the top, and sometimes intervene between the principal layers. The middle layer resists the action of the elements and is susceptible of fine dressing. Although the color of this limestone is a bluish-gray where the face of the ledge is exposed, it weathers with a peculiarly-wrinkled, russet-colored appearance. It is highly valued as a furnace flux, and is used chiefly at Allegheny, Pennsylvania, Wheeling, West Virginia, and Mingo Junction and Steubenville, Ohio.

TRIASSIC.—At various places near the South mountain, in Pennsylvania and Maryland, the Triassic (Mesozoic) formation consists of a calcareous conglomerate, made up chiefly of fragments of the magnesian limestone upon which it rests, and which bounds it on the northwest, cemented with a red clayey material, very calcareous from infiltration, and in Maryland called Potomac marble. When polished, the stone presents a very singular but pleasing appearance from the numerous fragments of which the mass is composed. A chemical analysis shows its ingredients to be about the same as those of the limestone, from which it is chiefly made up. A specimen from near Fairfield, Adams county, forwarded by A. E. Lehman, of the Pennsylvania geological survey, proved to be a dolomite, containing considerable reddish residue, clay-cementing material, and a little iron, which gives the clay its reddish color. It is here burned for lime. Its local name is "calico rock", from its peculiarly diversified appearance.

SANDSTONES.

TRIASSIC.—The geographical limits of the belt of Triassic age passing through southeastern Pennsylvania are described in the geological reports of that state as commencing at the west bank of the Hudson river in a broad belt extending from the bay of New York to the base of the first ledges of the Highlands, and as bounded on the northwest by this chain and its continuation; southwestward it traverses New Jersey, Pennsylvania, Maryland, and, in a more interrupted manner, Virginia and part of North Carolina, so that its total length is not less than 500 miles, with a width in New Jersey of 20 miles between the Hudson and the Highlands. After crossing into Pennsylvania its breadth expands to nearly 30 miles, retaining this until it approaches the Schuylkill, when it contracts and maintains its course through Berks, Lancaster, Lehigh, Dauphin, York, and Adams counties, a breadth of about 10 miles between the Schuylkill and the Susquehanna rivers, and of 15 miles between the latter river and the Maryland state line. The south margin of the formation crosses the Delaware about $1\frac{1}{2}$ miles above the town of Trenton, and the north border crosses the Delaware at Durham, near Trenton. The geology of this formation is very simple, and is made up chiefly of red sandstones and shales alternately, the arrangement being in many places layers of sandstone of various thickness, with red shale intervening. The lowest portion of the formation is a conglomerate, chiefly made up of fragments of the primal rocks and limestones upon which it rests; then comes a considerable thickness of the red shales and sandstones, surmounted by the calcareous conglomerate, or "calico rock", just noticed. The sandstones in the middle part of this formation is the portion which produces nearly all the building stone at present quarried from the formation.

One of the principal quarries in Pennsylvania, on rocks of this age, is at Hummelstown, Dauphin county, a few miles east of Harrisburg. The material here is a brown, massive sandstone of a uniform and medium texture, and is quarried for caps, sills, trimmings, bases, steps, and other building purposes. It has been much used in Philadelphia, Harrisburg, Williamsport, Pottsville, Reading, Lancaster, York, Richmond, Baltimore, Washington, and other cities of the east. The ledge is 85 feet in thickness in this quarry, dipping perhaps 40° to the northward, and outcrops in places, the stripping setting in and increasing as progress is made into the hill. It may be observed here that the dip of this Triassic sandstone in Pennsylvania is almost universally in a northerly direction, and remains steadily between about 15° and 40° . But there are remarkable exceptions to this rule, as shown on the sheets of the topographical map of the Durham hills and Reading mountains (by Berlin and D'Invilliers), published in the atlas to Prime's Report D D D, *Second Geological Survey of Pennsylvania*. A considerable tract east of Reading is covered with south dips varying from 40° to 75° . There are south dips alternating with north dips along the Schuylkill below Reading, and Professor Frazer reports local anticlinals in York county.

The quarry is located on the south side of a hill. The stripping is not great, from the fact that the ledge is inclined at such an angle (40°) that it may be followed downward without the necessity of taking off much cover. The face of the quarry is at present about 100 feet, which is greater than the real thickness of the ledge, a fact due to its inclination. The rock is evenly bedded, and in courses varying in thickness from 3 to 10 feet. Blocks of as

a Under the Kittanning coal group, in the Lower Productive Coal Measures.

large a size as are desirable may be taken out. The jointing is rather regular, and the joints are from 4 to 40 feet apart. The topmost courses are of a reddish-brown color, resembling very much that of the Connecticut brownstone of the same formation, but the great body of the material is of a uniform, characteristic bluish-brown color, by which it is readily distinguished. Plate W represents a dressed surface of the Hummelstown brownstone. Among the buildings in which this stone has been chiefly used for trimmings are: In Washington, District of Columbia, the Bureau of Engraving and Printing and the residences of Hon. James G. Blaine, Senators Sherman and Cameron, and Colonel Jerome Bonaparte; in Philadelphia, the Academy of Fine Arts (basement), old Trinity church, Academy of Sciences (basement), and Philadelphia library. A slab from this quarry was forwarded to the National Museum which has every indication of having been formed by being sun-baked when in a soft, plastic state, the cracks being filled by material swept over them by the waves. In the quarries at Goldsboro', York county, the surfaces of some of the layers contain what resemble worm tracks or borings, and the stone is of a medium-fine texture, some of it conglomeratic, small siliceous pebbles being present; it is a reddish-brown in color, and has been quarried for caps, sills, steps, base courses, and trimmings generally, and is used in York, Harrisburg, Danville, Williamsport, and other cities in this part of Pennsylvania. Some of the trimmings in the Pennsylvania Capitol building are of this stone. It was not quarried during the census year. The total thickness of the ledge quarried is about 25 feet, in courses varying from 1 foot to 10 feet in thickness, with layers of red shale intervening between many of the courses of stone. The portions of the ledge nearest the surface are not so compact and durable as those below; this is, however, a characteristic of nearly all sandstone quarries. The distance from the railroad station is about $2\frac{1}{2}$ miles.

Along the line of the Philadelphia and Reading railroad, in the vicinity of Mohn's store, several miles south of Reading, Berks county, the Triassic sandstone, here a reddish-brown, massive stone of uniform medium-fine texture, not differing greatly in appearance from that quarried at Goldsboro', York county, is quarried from surface rocks, which are scattered thickly over the ground, and is used for steps, caps, sills, fronts, base courses, and other trimmings, chiefly in Reading, where several churches are built of it. The ledge of sandstone is found in place, but the stone is not quarried, as there is a supply of the surface rocks fully seasoned by the weather, furnishing a reliable and durable material, while some of the layers of the Triassic sandstone in place show themselves, when first quarried, to be susceptible to the action of dampness and frost, and need some care in seasoning. Many of the farm buildings through the area covered by this formation in Pennsylvania are constructed of the sandstone from it. The color is always some shade of brown, or reddish-brown, from the intimate dissemination of iron oxide through the cementing matter.

Within the limits of Norristown, Montgomery county, and the immediate vicinity of the city, the Triassic sandstone is quarried in a small way for local purposes, such as cellars, foundations, and ashlar for walls and fronts. The quarry just west of Bridgeport, across the Schuylkill from Norristown, ships a small amount of stone to Philadelphia. The location here is not far from the southern edge of the formation, and the stone quarried is from its lower strata, with a coarse, almost conglomeratic, texture and somewhat lighter color than the rock quarried higher in the strata. The total thickness of the ledge quarried here is about 14 feet, disposed in regular layers varying in thickness from 9 inches to 2 feet, some of which are separated by thin partings of the reddish clay. It is considerably jointed and broken. It is probable that layers of the stone lie below the bottom of the quarries at present opened in this vicinity. The stone presents a rougher appearance than that obtained from the same formation in most of the other localities where it is quarried, and it is of a lighter color, sometimes having only a tinge of brown. The color is not uniform throughout the quarries, and the buildings constructed of it in Norristown have a variegated appearance on this account, though there is not enough of variation to make the walls of the buildings present violent contrasts of color. This stone in the walls of buildings constructed of it over half a century ago still remains firm and durable, but its grade is not such as to make it important for other than local uses.

At Lumberton, Yardleyville, Center Bridge, and other places in Bucks county, near the Delaware river, the Triassic sandstone is quite extensively quarried for cellars, foundations, bridge abutments, and ashlar, and is shipped chiefly to Philadelphia by rail and boat; it is also shipped to Camden, Norristown, and neighboring places. The material here is of medium texture, with indistinct signs of stratification, and usually of a light brown color. The quarries are on the lower portions of the strata. The bedding is fine and the courses are thick and regularly jointed, being usually from 8 to 20 feet apart. Among the buildings constructed of this material are the Bucks County court-house, at Doylestown; the insane asylum, Norristown; approaches to the South Street and Callowhill Street bridges; the Catholic churches at Lehigh avenue and Diamond street, and the wing of the Episcopal hospital, Philadelphia.

At Newton, in Bucks county, a small amount of stone is quarried, the material being similar and used for the same purposes as that at Lumberton and Yardleyville.

The stripping in all of these red-sandstone quarries is a red clay, and varies in depth from nothing to 12 or 15 feet, excepting in the Hummelstown quarries, where the stripping is sometimes greater. As the ledge always has considerable dip, it outcrops in places and the stripping increases more or less rapidly according to the topography of the ground.

LOWER SILURIAN.—Outside of the Triassic border to the north and west, middle Pennsylvania is a country of parallel sandstone mountains and shale and limestone valleys, of which the principal sandstone formations are the Oneida and Medina (No. IV), the Oriskany (No. VII), the Catskill (No. IX), the Pocono (Vespertine, No. X), and the Pottsville (Seral, No. XII); but in none of these except the Catskill have quarries of building stone been opened for commercial purposes, although the sandstones and conglomerates have been locally used for building purposes.

The South mountains, which rise immediately from the north border of the Trias belt, are made up of Laurentian gneiss overlaid by Potsdam sandstone between the Delaware and Schuylkill rivers, and of Potsdam sandstone and Huronian porphyries between the Susquehanna river and the Maryland line.

The Welsh mountain, on the south edge of the Trias belt, in Chester and Lancaster counties, is Potsdam sandstone overlying (Laurentian?) gneiss. This Potsdam sandstone formation extends westward underground beneath the limestone plain of Lancaster and appears on the Susquehanna river above Columbia.

Both above and below the Potsdam sandstone (quartzite) proper lie schists or slates which belong to the same formation and ought to bear the same name. The upper slates are calcareous and underlie the great Magnesian limestone (Lower Silurian) formation of the Cumberland valley.

There is a quarry of Potsdam sandstone at Columbia, Lancaster county, in beds immediately underlying the Siluro-Cambrian limestone. It is used only for cellars, foundations, furnace stacks, and work of that class in Columbia, Harrisburg, and vicinity. The height of the face of the quarry is about 110 feet, in layers varying from 3 to 20 or 30 feet in thickness. The strata are perpendicular and are sandwiched between strata of magnesian limestone. The horizontal measurement across the face of the quarry is from 1,200 to 1,300 feet. These two formations apparently form an anticlinal axis from which the top has been eroded. The stone is invulnerable to the attacks of the weather, is dry, and will absorb but little moisture; it has no regular cleavage and is somewhat difficult to get into proper shape for any but the ruder uses. It stands a high degree of heat. The material is fine-grained, calcareous, massive, compact, gray in color, having somewhat the appearance of an argillaceous schist, and breaks with a very irregular fracture.

In Northampton county, near Bethlehem, there is a fine, massive, gray, hard, and rather quartzitic sandstone of the Potsdam formation, lying in thick layers and irregularly jointed, quarried for local purposes.

UPPER SILURIAN.—Rocks of Upper Silurian age are but very little quarried in Pennsylvania for building purposes.

Two miles north from Danville, on the line of the Bloomsburg division of the Delaware, Lackawanna, and Western railroad, and on the north branch of the Susquehanna river, in Montour county, rocks of the Clinton subdivision of this formation are quarried for building purposes and for heavy foundations. It is a dark gray sandstone, massive, fine in texture, evenly bedded, and lies in medium to thick courses. This stone was used in the construction of the Danville insane asylum.

Near Mapleton, Huntingdon county, at the west entrance of Jack's narrows, a deep gap in Jack's mountain, letting the Juniata river and the Pennsylvania railroad pass through, the face of the mountain is covered with surface rock of Medina sandstone to a depth of 50, perhaps 100, feet or more in places, making the mountain appear from some points like a huge stone heap. The stone is a light gray in color, of medium texture, irregular in stratification, very hard, and only less brittle than the limestone much quarried in the mountain region of this part of the state for railroad ballast. The stone here is used for railroad ballast and bridge abutments on the Pennsylvania railroad. It is very durable, resisting the elements well; blocks large enough to produce stone for bridge abutments do not occur often enough to furnish a convenient supply. Considerable selecting is necessary when blocks of this kind are desired, but the blocks are flat-bedded and large enough to be used for foundation and cellar work and for ashlar. The only labor necessary at this quarry is the breaking of the stone and sending them down the chute to the cars below. For description of Medina sandstone in Juniata valley see Report F, *Second Geological Survey of Pennsylvania*.

At the upper end of Jack's narrows the Oriskany sandstone is quarried extensively for glass-sand; it is too friable at this point to answer for building purposes. The strata stand vertical or with a very steep westerly dip.

DEVONIAN.—At Weissport, in Carbon county, there is a fine, thin, and evenly-bedded carbonaceous sandstone of the Marcellus Shale age quarried to a limited extent for flagging and other uses at Weissport, Mauch Chunk, and Bethlehem; it is dark gray, approaching black in color, due probably to the carbonaceous matter in it. The depth of the material quarried is about 12 feet, out of which about 5 feet are suitable for flagging, the workable material being disposed in beds a foot or two thick through the mass. The flags are from half an inch to 8 inches in thickness; dip of the strata, 20°.

The Marcellus shale in this vicinity is reported to contain sufficient carbonaceous matter to occasionally amount to a thin streak of bituminous coal; and this is a characteristic feature of the formation in many counties of the state. In Perry county it contains numerous thin streaks of coal.

Next in order, progressing to the northward, in eastern Pennsylvania are the Catskill beds, which contain the flag-stone quarries of the Delaware River valley, above Port Jervis, in Pike county. The rocks here quarried have been by the *Pennsylvania Geological Survey* named "Delaware flags". They are quarried chiefly for sidewalk

paving and other flagging, and for curbs and trimmings. It is dark grayish, usually massive, but sometimes indistinctly stratified, fine, compact, and hard in texture. It lies usually in even parallel layers from 1 inch to 12 inches and upward in thickness. It is marketed in Philadelphia, Newark, New York, New England, and Washington, and is known as the New York blue-stone, going into the market with stone from Ulster county, New York, from which material it is scarcely distinguishable.

The surface of the country in this section is very hilly and rugged. The strata are nearly horizontal, and the roughness of surface has been produced by erosion simply.

The flags are quarried along the face of the steep cliffs, on both sides of the river, at a number of convenient points where the fallen débris is not too thick. On starting a new place the quarrymen usually have to remove about 6 feet of worthless rock, getting about 4 feet of flags, increasing from 1 inch to 12 inches in thickness from the top downward. Below this the layers continue to increase in thickness, and are considered too thick for flagging. Machinery has not been used except as an experiment. Some of the Pike County flag-stone is quarried at higher elevations and is of a somewhat lighter color than that which is quarried lower. The method of transportation to Philadelphia, where much of the stone is used, is by canal to Rondout on the Hudson, thence round by water, but to points in New York, New England, and New Jersey usually by rail, so as to avoid transfer.

The Catskill sandstone is quarried in the mountains near Scranton, chiefly for local use in bridge abutments, cellars, and foundations. It is here of a buff color, medium hard in texture, indistinctly stratified, and lying in even parallel seams from 3 to 20 inches in thickness; the joints are usually from 12 to 15 feet apart. The quarry is located in a mass of stone exposed on the northwest side of the mountain west of Scranton. There is no stripping; the dip of the strata northwestward is about 25° ; the thickness of the beds quarried 30 feet. The blocks readily break into rectangular shapes with proper management. As nothing but cobble pavement, and but little of that, has thus far been used in Scranton and neighboring towns, there has been no demand that would justify a trial of the experiment of shaping this stone into paving blocks. It is stated in the geological reports that the lithological characteristics of this ledge are those of the Pocono sandstone, but that there are some stratigraphical relations that indicate it to be Catskill.

In the mountains a few miles east of Wilkesbarre, in Luzerne county, the Catskill red sandstone is quarried for sidewalk-paving, caps, sills, and ashlar. The stone here is quartzitic in appearance, of medium texture as to firmness, and lying in even parallel courses of thin to medium thickness, with beds inclined at various angles according to locality; the joints range from 20 to 40 feet apart. It is shipped by rail to Wilkesbarre, Allentown, Bethlehem, Easton, and neighboring towns. This formation is the principal one exposed on the side and crest of the mountain which borders the Wyoming valley on the east. The soil on the mountain is sterile and scant from the slow weathering of the rock. There is but a scanty growth of cedar, hemlock, pine, and scrub brush, the crests of some of the ledges being entirely bald. The thickness of the workable stone in the quarries now opened is from 8 to 10 feet, in courses from $1\frac{1}{2}$ inches to 2 feet in thickness, the thin layers lying usually near the top, but sometimes intervening between thicker layers. Nearly all of the sidewalks in Wilkesbarre are paved with this stone. In the locality where the quarrying is done at Laurel run the dip of the strata is into the mountain. The stripping increases very rapidly, and the quarrymen keep around the skirt to avoid deep stripping.

The Chemung beds of Wyoming county rank very high in the production of building stone. The material is quarried for all building purposes, and chiefly for caps, sills, bases, monuments, and trimmings. It is used in New York, Philadelphia, Boston, and Washington. The stone is fine, compact, massive, dark bluish-gray in color, lies in even parallel layers from a few inches to 6 feet or more in thickness, the courses at the top being usually thin, and increasing in thickness downward; the thicker beds are quarried extensively for flagging. The surface of the country is very broken and hilly, the hills being usually steep and rocky, showing the resistance of the stone to decomposition. Beds of good stone for flagging and general building purposes are found here and there at all elevations, flaggings of the same quality, texture, and general appearance being found at the foot and at the summit of the same hill; from 6 to 20 feet of good stone may be found at one place. The abruptness of the hills usually causes the stripping to increase rapidly; the strata are nearly horizontal, the broken character of the country being caused by erosion. This stone does not scale or crumble. The expense of dressing the stone is comparatively high, but it is thought to fully repay for its costliness by the handsome and substantial character of the work constructed of it. The quarries at Black Walnut, Skinner's Eddy, and Nicholson, all in Wyoming county, are of the same formation, and the material is the same as to quality. Gang and rip saws, rubbing-beds, and turning-lathes are used in dressing the stone. This stone has been used in the construction of the Produce Exchange building, the residence of Mr. W. J. Hutchinson, on Fifty-eighth street, and that of Mr. Addison Hutton, Fifth street, New York city; the residence of Mr. A. J. Dull, at Harrisburg, and the carved work for the interior decoration of St. Mark's Episcopal church at Mauch Chunk, Pennsylvania. Other quarries in this vicinity produce flagging exclusively from the thinner layers. The surface layers are usually not solid, but have a sort of laminated structure, and can readily be split into thin plates; such flags prove to be inferior, on account of the separation of these plates by the water and frost. Considerable of the stone from these layers is shipped, but sells at a lower price. The lower courses are solid, quite substantial, and durable. For the past few years the amount of flagging shipped from this locality each year has been more than double that of the preceding year.

In beds at apparently the same horizon as those quarried at and near Meshoppen, stones similar in character are quarried for flagging, steps, water-tables, caps, sills, and monument bases, at Nicholson, about 20 miles east of Meshoppen, and are shipped to Scranton and vicinity and Easton, Pennsylvania, and to Hoboken and Morristown, New Jersey. Twelve feet in thickness of the ledge is quarried, but the bottom has not been reached. The courses are very even, and parallel and horizontal, varying in thickness from 1 inch to 3 feet, the thinnest layers at the top, though thin layers often intervene between the thicker ones. The section of country in which the quarry is situated is hilly and broken, caused by erosion, apparently, as the strata are all horizontal. The hills are made up mostly of stone, generally lying in thin layers. Where the quarries are located at the base of these steep hills the stripping increases rapidly.

At Brandt, in Susquehanna county, on the Delaware and Hudson Canal Company's railroad, the Chemung beds are quarried for flags, curbing, crossings, caps, sills, and other trimmings, which are shipped to Elmira and Binghamton, New York, and to Scranton, Pennsylvania, and vicinity. The stone is massive, fine and hard in texture, dark gray in color, and lying in even parallel courses from 2 to 8 inches in thickness; the joints are 10 feet and more apart. Where quarried there are about 25 feet in stripping of cap or worthless rock, under which is a bed of good flagging 12 feet in thickness, lying horizontally; flags at the top are about 2 inches thick, and they increase very regularly in thickness downward, the bottom flag being 12 inches thick; beneath the flagging is a bed of brittle, crumbling slate. The surface of the country here is very rough and broken, and beds of the flagging occur at almost every elevation.

At Mainsburg, Tioga county, the Upper Chemung beds are quarried for paving flags, which are shipped to the neighboring towns in the south-central part of New York. The stone is dark gray, sometimes massive, and sometimes distinctly stratified, lying in even, thin, and horizontal courses. The bed of the quarry is about 8 feet in thickness, covered by a solid stratum of hard, dark-colored shale, which is removed by drilling and blasting. The courses are from 1 inch to 8 inches in thickness, most of them being less than 4 inches. The 3- and 4-inch courses make very desirable material for sidewalk flagging, the thinner courses being adapted only to use in pavements which are not required to sustain much wear nor heavy shocks. The natural blocks are usually nearly square and quite evenly and smoothly bedded. The bed will at the present rate soon be exhausted in the hill where it is now quarried, but it is probable that in some of the surrounding hills beds of equally good quality exist. An ordinary paving material is quarried in the Red Catskill formation near Wilkesbarre and Osceola, Tioga county.

Sandstone of Chemung age is quarried at Farrandville, Clinton county, for ordinary building purposes, and is used chiefly at Danville, Montour county, Pennsylvania. It is buff in color, massive, and of medium texture, lying in even courses of varying thickness. The front and tower of the Bloomsburg jail, the Memorial church at the same place, and the Danville National Bank building are constructed of this stone.

At Queen's run, in Clinton county, Devonian rocks of Catskill age are quarried for foundations and bridges, and are used chiefly at Lock Haven, to which place they are transported by water. The stone is fine in texture, indistinctly stratified, dark gray and brown in color, and lying in even courses of medium thickness. The use to which this stone is most applicable is curbing; it is used in the rough for cellar walls and bridge abutments, sometimes rough-pointed for these purposes. Some of the courses make an ordinary material for sidewalk pavement. The stone has been quarried at various localities in the vicinity along the bank of the river. The strata of quarry rock are found at different horizons; they are usually but a few feet in thickness, and the dip soon carries them under, so that they are not quarried extensively at any one locality.

The Oriskany sandstone has been extensively quarried for bridge abutments and wall stone near McVeytown, and is used for bridge abutments and wall stone at Harrisburg, Pennsylvania, and along the line of the Pennsylvania railroad, chiefly on the middle division. It is gray in color, coarse in texture, its stratification is even and parallel, lying in even, regular courses of varying thickness. Up to the present time only the surface rocks have been quarried at this place; they are scattered over the sides and top of a low anticlinal ridge of Oriskany sandstone lying just east of McVeytown and parallel to Jack's mountain, which rises a couple of miles to the west. It is estimated that \$1,000,000 have been expended on this ridge in quarrying and preparing this stone, chiefly for bridge abutments on the Pennsylvania railroad. It is rather rough in texture, but very hard and durable. The sandstone usually has a ripple-marked surface, but the natural blocks are usually rectangular in shape and nearly as regular as if sawed. The much-weathered rocks on the crest of the ridge exhibit casts of a brachiopod (probably the *Spirifer arenosus*) in abundance. There is yet a large supply of the stone in the shape of surface rocks, and, because less expensive, they will probably all be removed before the rock in place is touched.

The sides of the mountain near Altoona, Blair county, are thickly strewn with surface rocks of different formations, chiefly Catskill, Pocono, Pottsville conglomerate, and Mahoning sandstone, which furnish nearly all the building stone for cellars, foundations, terrace walls, and other ordinary building purposes, and is used in the town of Altoona and vicinity. These surface rocks are gray in color, and, though varying much in color and texture, are usually very hard and durable; on breaking up they exhibit many cracks and fissures, due to the effects of fire passing over the mountains. The material is too rough and hard to dress well, and is only suitable for the ruder building purposes.

At Leboeuf, Erie county, the third oil-sand, locally so called, which is of Devonian age, produces a sandstone used at Erie for foundations, bridges, flagging, sills, and other trimmings. It is gray in color, fine in texture, distinctly stratified, and evenly bedded, the courses being of medium thickness. This formation produces the best building stone quarried in Erie county. When seen in the stone-yards, fresh from the quarry, it can hardly be distinguished by its general appearance from some of the stone quarried at Berea, Ohio. By some geologists the third oil-sand was for a long time supposed to be the equivalent of the Berea grit in Ohio, but it is now pretty generally admitted that the Corry sandstone, several hundred feet above the third oil-sand and above the whole Venango oil group, is the equivalent of the Berea grit. The Corry sandstone in Pennsylvania does not possess the valuable characteristics of its equivalent, the Berea grit, in northern Ohio. There are a number of quarries worked to a limited extent in the third oil-sand in Erie county. The rock of this formation has been quarried in different localities at different times for local and temporary demands, but there are few permanently-worked quarries in the county. The rock contains petroleum and soluble sulphates in such large quantities that it is not a desirable material to be used in fine buildings. Builders say it "sweats and spoils everything below it". It is, however, a good material for bridge-building and other like purposes. The stratum in the quarries is about 11 feet in thickness, the courses varying from 8 inches to 3½ feet thick. A section of the quarry is as follows:

Drift deposit	6 feet.
Blue shale	6 feet.
Coarse conglomerate	1 foot 6 inches.
Quarry rock, sometimes containing pebbles, especially between the beds	7 feet.
Quarry rock, clear, fine-grained sandstone, beneath which shale appears	4 feet.

The stone is quarried chiefly on the left bank of French creek. The stripping constantly increases as the excavation is carried farther into the bank. The outcrop of the quarry rock is about half a mile in length, and a large amount of the stone may yet be quarried with a little increase of stripping.

At Jackson station a quarry is opened in the third oil-sand formation, and experiments are being made with the rock with the expectation of successfully marbleizing it for mantels in the same manner as the Euclid (Ohio) stone.

Devonian rocks of Portage age are quarried a few miles east of Erie for foundations in that city. The stone is gray in color, fine in texture, indistinctly stratified, and evenly bedded in layers of medium thickness. The principal quarry is in a stratum of fine-grained sandstone from 20 to 30 feet in thickness; in some places there are two or three courses from 6 to 12 inches thick, and in some places the stratum is solid. The rock contains petroleum and other soluble impurities which make it unfit for use in all buildings exposed to the atmosphere. Other quarries of the same rock are quarried near the lake shore, the quality of the rock being about the same in all the quarries on this formation near Erie. A blue, impure sandstone in the Chemung flags is quarried occasionally to a limited extent at different localities in the vicinity of Erie.

SUB-CARBONIFEROUS.—Rocks of the sub-Carboniferous formation in Pennsylvania have thus far been quarried but little for purposes of construction. It will be noticed that there is but one limestone quarry of importance located on rocks of this age in Pennsylvania, and the following description will give an idea of the extent to which the sub-Carboniferous sandstones are quarried in the state:

Three miles north of Scranton, in Lackawanna county, in the side of the mountain a short distance westward of that city, and close to a quarry in the Catskill sandstone before mentioned, there is a quarry located on rock, probably, though not certainly, of Pocono sandstone of sub-Carboniferous age. The stone is much softer than that in the quarry of Catskill sandstone, and produces the best cutting stone in the vicinity; it is used for base courses, caps, sills, and other trimmings at Scranton, and was used in the construction of the Megargill and Cornell bank in that city. There are 26 feet of workable stone in this quarry, the thickness of the layers being from 3 inches to 2 feet, with the thinnest at the top, although thin layers occasionally intervene between the thicker ones. The dip of the strata is about 25°.

Two miles northwest of Altoona, in Blair county, on the Pennsylvania railroad, sandstone, probably of Pocono age, is quarried for cellar walls and foundations in Altoona. The material is gray, of medium texture, evenly and distinctly stratified, evenly bedded, and in courses varying from 1 foot to 4 feet in thickness. The stratum is much jointed, being usually not farther apart than from 5 to 10 feet. The total thickness of the ledge is about 15 feet. The stratum inclines about 45°, and dips into the hill in such a way as to increase the stripping very rapidly, so that it is not practicable to follow the ledge far into the hill.

Four miles southeast of Uniontown, at the west foot of the Chestnut ridge, the Pocono sandstone is quarried for lining steel furnaces, cupolas, and converting-furnaces. It is used chiefly at Pittsburgh and at Braddock's Field, Pennsylvania, and Saint Louis, Missouri. It has been used in the construction of cellars and foundations. It might be used for ordinary building purposes, but is rather hard to dress; and there is such a demand for it as firestone that the latter will probably continue to be the principal purpose for which it will be used. It is light gray in color, of medium-fine texture, irregularly stratified, evenly bedded, in courses varying in thickness from 2 or 3 inches to 8 inches. Only about 15 feet of the stratum is quarried, and the courses below are probably thicker. The Pocono sandstone in this locality is found also on the top of the synclinal arch of Chestnut ridge, the inclination of the strata

being such as to bring it near the surface at nearly every point on the west side of the mountain. It is quarried about a mile up the side of the mountain, at Turkey's Nest, on the National road, as it has been quarried at the summit of the mountain above, where the stone is said to be superior to that at the other points mentioned, but transportation is so costly from the summit that the quarry there is not operated at present.

At Venango, in Franklin county, the Chenango sandstone, a subdivision of the sub-Carboniferous rocks in Pennsylvania, and known in Warren, McKean, and neighboring counties by the name "sub-Olean", or "flat pebble rock", is quarried for sidewalk paving and general building purposes, and used in Franklin and Oil City. It is gray in color, fine and uniform in texture, evenly and distinctly stratified, evenly bedded, and lying in courses from 1 inch to 30 inches thick. This formation, like the Corry sandstone, was supposed for a time to be the equivalent of the Berea grit in Ohio. In this locality some portions of it somewhat resemble the Amherst "buff" stone in appearance, and other portions have very much the appearance of the Amherst "blue"; and the material is more nearly equal to the famous Ohio stones mentioned than is that of any other quarry in northwestern Pennsylvania. The thicker courses, from 4 to 6 inches in thickness, are used largely for sidewalk paving, and large blocks from the heavier courses can be split into thin slabs by means of wedges. These quarries are located in the right bank of the Allegheny river.

On the opposite side, about one mile back from the river, is a quarry which has been worked quite extensively in the past for paving stone. The layers vary in thickness from 1 inch to 6 inches, and the stone is very micaceous and tough. The stratum of quarry rock in all these quarries is about 15 feet in thickness. The amount of stripping rapidly increases as work is carried farther into the banks.

The Chenango sandstone is also quarried at Titusville, Crawford county, for local use in bridges and foundations. It is here gray in color, massive, coarse in texture, evenly bedded, and in thick layers. The rock from this stratum is used more than any other for building purposes in Crawford county. It is usually colored with peroxide of iron, nodules of which frequently occur from a quarter of an inch to 2 inches in diameter; the color is not uniform, though seldom disagreeable to the eye. The texture differs but little from that of the stone obtained from the conglomerate measures above, except that it is usually more uniform. The rock in most localities very much resembles the Waverly conglomerate of Ohio, and if the following correlation can be sustained the two formations are identical:

CARBONIFEROUS CONGLOMERATE.

CRAWFORD COUNTY, PENNSYLVANIA.

Chenango group:

Shales	1 = 1.
Chenango sandstone	2 = 2.
Meadville group	3 = 3.
Sharpsville flags	4 = 4.
Orangeville blue slate	5 = 5.
Corry sandstone	6.

OHIO.

Cuyahoga shale:

Shales.
Waverly conglomerate.
Shales.
Buena Vista stone.
Berea shale.
Berea grit.

But so far as the economic value of these different formations is concerned their identification is of little consequence. The highly valuable deposit of Berea grit in northern Ohio becomes an almost worthless rock within 100 miles east of where it has its maximum development. The Chenango sandstone is usually an ordinary coarse-grained rock, but near Franklin, Venango county, Pennsylvania, it is a uniform, fine-grained sandstone, and is perhaps the most valuable sandstone deposit in western Pennsylvania.

The Sharon conglomerate, existing over an extensive territory and locally known by various names, as "second mountain-sand", and "Ohio," "Garland," and "Olean conglomerate", is in some localities a mere mass of quartz pebbles loosely cemented together, and in texture varies from this to a fine-grained blue-black stone. It is quarried near Greenville, Mercer county.

CARBONIFEROUS.—As before stated, the Carboniferous rocks in western Pennsylvania and the isolated tracts of the same area in the anthracite regions of the northeastern part of the state, have thus far produced scarcely anything but sandstones for building purposes, and the general statement may be made that they were quarried only for local use. These sandstones intervene between the different beds of coal in the Coal-Measure formations, and are often of coarse and conglomeratic texture, though occasionally fine and compact. The anthracite region gets its supply of building stone mostly from the Chemung, Catskill, and other Devonian rocks quarried at Meshoppen and Nicholson, Wyoming county, and at various places in the mountains extending through the region, and the Carboniferous sandstones are but little drawn upon.

At Shickshinny, Luzerne county, on the Bloomsburg division of the Delaware, Lackawanna, and Western railroad, there is a quarry of sandstone of Carboniferous age quarried chiefly for bridge-building and other railroad work on the line of railroad above mentioned. It is a dark gray sandstone of medium texture, evenly and distinctly stratified, evenly bedded, the layers at the top being 2 inches thick, and at a depth of 100 feet 4 to 6 feet thick. The top stone is used for sidewalks at Wilkesbarre and other towns along the banks of the Susquehanna river, and at Danville, Scranton, and Lancaster. The jail at Danville is built of this stone, and also the side walls of the Bloomsburg jail.

Progressing northward and westward from the anthracite region we come to the Carboniferous rocks in Tioga county. At Antrim, in that county, they are quarried for bridge work and general building purposes, and are used chiefly at Corning, New York. An Episcopal church at Antrim, and a court-house at Wellsboro' are built of this stone. It is light gray, massive, and coarse in texture, evenly bedded, and in thick courses. Much of the material obtained here is almost a purely white sandstone; it is a strong and durable rock, and holds its color well. It presents the best appearance when used in connection with a dark-colored stone, as is well shown in one of the county buildings at Wellsboro', the white sandstone structure being trimmed with white Medina sandstone. It works rather hard under the chisel, and its use is thereby greatly limited. There are indications, however, that if the excavation were carried farther into the bank a softer material would be obtained where it has not been so thoroughly drained; or, in the language of the quarrymen, "where it still contains the sap."

Near Somerset, in Somerset county, there is a flag-stone quarried and used locally for sidewalk paving. It is gray in color, of medium texture, irregularly stratified, very evenly bedded in thin layers, and but little jointed. The total thickness of the ledge is not exposed; it is quarried to a depth of 6 feet only, coming out in blocks varying in thickness from 2 or 3 to 10 inches, the average being from 4 to 6 inches. The general shape of natural blocks is exceedingly regular, presenting, however, an apparently ripple-marked surface. The flags are very hard and would be difficult to dress to a smooth surface, but they resist foot-wear exceedingly well.

At Johnstown, in Cambria county, the Mahoning sandstone, at the top of the Lower Productive Coal Measures, is quarried for general building purposes and used locally. It is dark gray, massive, medium, but uniform texture. The stratum of quarry rock is about 20 feet in thickness, the courses varying in thickness from 8 to 32 inches; there being one 32-inch course near the middle of the stratum. This is the firmest and most uniform in texture, and the most durable material for steps, for which purpose it is largely used. There are thin beds of ferruginous, shaly material between some of the layers. Sometimes this ferruginous material amounts to a thin layer of rich, compact iron ore. The stone itself is ferruginous, and when freshly quarried presents a compact, bluish appearance, flecked through with minute spots of peroxide of iron; and when exposed for a time it changes to a rough reddish-brown color to a depth of 5 or 6 inches. There is a layer about 4 feet in thickness about the center of the ledge. It is so ferruginous as to render it inapplicable to building purposes.

The Homewood sandstone (which is the uppermost of the three subdivisions of the Pottsville conglomerate formation, No. XII, underlying the Coal Measures) of the Pennsylvania geological reports is quarried for bridge construction at Iowa station, Jefferson county, on the Allegheny Valley railroad, and used on the low-grade division of that road. It is a gray, massive, coarse stone, evenly bedded, and in thick courses. Ordinary stone for foundations, bridge abutments, and work of that class can be obtained almost everywhere along this line of railroad from Driftwood to Red Bank; the best perhaps is found in the immediate vicinity of Brookville. It has been used in this town extensively, but only detached blocks have been quarried. The railroad company does not always obtain stone in the same locality, but moves from place to place according to convenience.

At Freeport, Armstrong county, the Mahoning sandstone is quarried for bases and steps, and used along the line of the Pennsylvania railroad from Allegheny to Tyrone. It is gray and light brown in color, irregularly stratified, coarse texture, unevenly bedded, and in courses of medium thickness. This stratum has a much better development farther north, in Clarion county, and it has been quite extensively quarried near Catfish in that county, and near Logansport, Armstrong county. The stone for the construction of the court-house at Kittanning and that for the construction of the new jail at the same place were obtained near Catfish. The texture of the stone differs but little in these two localities, but the color of the Catfish stone is lighter and more uniform than that of the Logansport stone. At these localities the material is quite free from mica.

About 2 miles north of Penn Junction on the Allegheny Valley railroad the full thickness—20 feet—of the stratum is exposed; here the upper and lower portions are quite micaceous, and the middle portion contains very little mica. At the Freeport quarry mica scales are found in abundance from the top to the bottom of the stratum; here the color of some portions of the rock is brown and other portions light bluish or nearly white. The darker portions have the reputation of being quite durable, but the lighter portions are not so. The stone from Catfish and Logansport wears away rapidly when used for steps and door-sills, but lasts quite well when merely subjected to atmospheric action. It is easily broken by concussion, but is capable of withstanding considerable pressure.

A quarry near Cowanshannock, a few miles north of Kittanning, has been worked quite extensively from time to time. From this and the Catfish quarries stone has been largely shipped to Allegheny and Pittsburgh.

Mahoning sandstone is quarried at Lucesco, the junction of the Allegheny Valley and West Pennsylvania railroads, on the Allegheny river, in Westmoreland county, and used chiefly for cellar walls and foundations for manufacturing establishments at Pittsburgh. It is employed to some extent for caps, sills, and other trimmings; it is gray, irregularly stratified, and of medium texture, evenly bedded and in thick courses, though much broken at the outcrop. The total thickness of the ledge of the quarry is 60 feet, with indications that it will be found thicker as the quarry progresses in the hill. The hill is so steep at this point that the stripping must increase rapidly unless the ledge sets in more heavily to compensate. The material of the upper 40 feet of the ledge is rather coarse in texture,